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Equipment for Loading Test Slugs & Flight Bodies
Operating Instructions

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DEFENCE RESEARCH ESTABLISHMENT SUFFIELD

Contract Report
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Canada

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EQUIPMENT FOR LOADING TEST SLUGS & FLIGHT BODIES

OPERATING INSTRUCTIONS

A Report to the

DEFENCE RESEARCH ESTABLISHMENT SUFFIELD

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Equipment for Loading Test Slugs & Flight Bodies

Operating Instructions

1.0 Introduction

The Defence Research Establishment Suffield is planning to conduct experiments on the flight of hollow bodies through combustible gas. To achieve the high velocities needed to initiate combustion during flight, a large (155 mm) cannon will be employed to fire lightweight bodies into the gas.

A specially designed, electrically fired, propelling charge is used to operate the gun at high muzzle velocities.

This report is concerned with the operation of appliances designed for the loading and seating of the hollow bodies into the gun In addition, the mechanism for introducing the firing circuit wiring into the powder chamber is dealt with, as well as equipment used in circulating the combustible gas.

The items of equipment and the topics addressed are listed below:

1. Electrical feed through units
2. Shaft packing for the combustion gas circulation fan
3. The projectile ramming system
4. Tools for inserting test slugs and hollow flight bodies into the gun bore
5. Procedures for inserting and ramming test slugs and hollow flight bodies

Operating instructions are given in separate sections of this report, with each section devoted to one item of equipment. For quick reference the drawings and photographs mentioned are included with the text. Detail drawings are attached as appendices.

2.0 Electrical feed through units

2.1 Function

The feed through units are used to provide for direct entry of the firing circuit wires into the gun powder chamber.

2.2 Operating conditions

The primary design conditions are:

1. Leak proof entry of the electrical circuit into the gun interior
2. To provide for low electrical resistance and adequate electrical isolation

The gun propelling gases are extremely hot, (2500°K), and develop high pressure, (50,000 PSI).

2.3.1 Electrical path

Reference is made to the drawing titled "Feed Through Assembly". The firing pulse is transmitted to the feed-through by a heavy insulated copper wire, noted as #1 in the drawing referenced above. This wire is fitted with a terminal lug, #3, using a soldered connection to obtain reliability. The terminal is secured to a central conductor #9, with two brass nuts #4. The conductor is isolated electrically from the feed-through housing #11, with a series of plastic and fibre parts. These are listed below:

Electrical insulating parts

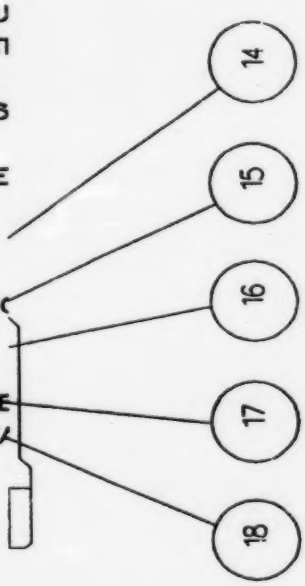
#10	Connector sleeve
#18	Washer, load bearing
#17	Insulator, sleeve
#16	Insulator, seal
#15	Wedge
#14	Seal, Feed-through

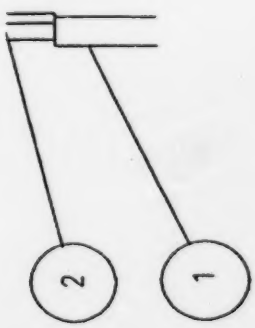
At the inner end, a small brass screw #8, secures two small wires #5, to the conductor, using a terminal lug. Soldered connections are used to obtain reliability. The small wires connect with squibs for initiating the propelling charge.

FEED-THROUG
SHEET
DATE : 2C
FILE : D2 - FE

FEED THROUGH ASSEMBLY
DATE : 20 MAR 99
FILE : D2 - FEEDTASY .CAD
SHEET 1 OF 2

DRAWING FIND No.	QTY.	DESCRIP
1	*	LEAD WIRE FROM DR LENGTH LESS THAN !
2	1	SOLDERED CONNECT
3	1	TERMINAL LUG, SPAE
4	2	NUT, BRASS, SIZE N
5	2	LEAD WIRE TO SQUIE
6	1	TERMINAL, SPAENAU
7	2	SOLDERED CONNECT
8	1	SCREW, #0-80-NF, SPAENAUR - MS926
9	1	CONDUCTOR
10	1	CONNECTOR SLEEVE
11	1	HOUSING
12	1	PLUG
13	1	SEAL - WASHER
14	1	SEAL - FEED THROUG
15	1	WEDGE
16	1	INSULATOR - SEAL
17	1	INSULATOR - SLEEVE
18	1	WASHER - LOAD BEA





2.3.2 Mechanical details

During firing, the propelling gas enters the feed through housing along the route of the small wires #5. The gas pressure is checked internally by the seal #14. The wires are destroyed by the gas during firing.

The life of the seal can be prolonged by the use of a refractory luting compound packed into the internal space, adjacent to the connection point of the small wires.

External gas leakage is prevented by the copper washer #13.

2.4 Location

The feed through units are mounted at the breech end of the gun, spaced about one meter apart over the top of the powder chamber. The gun tube is equipped with small diameter holes drilled through to the powder chamber. These drillings provide a passage for the wires. At these locations, threaded counter bores (metric threads, M10 x 1.0), are provided for mounting the feed through units.

2.5 Installation

In preparation for firing, the feed-throughs are disassembled, cleaned, and equipped with new seals.

The conductor is partially assembled to the seal-feed through #14, the wedge #15, and the insulator-seal #16.

The firing circuit wires are then threaded into the feed-through housing, and then through the copper washer #13. After this they will be fastened to the conductor using screw #8.

Feed-through assembly is then completed.

Next, the small wires are threaded into the drilling on the gun, with length sufficient to make connections in the powder chamber. The complete unit is then screwed into place on the gun, and the lead wires trimmed in the powder chamber.

2.6 Drawings

Detail drawings of the feed-through parts are given in appendix A.

3.0 Shaft packing for the gas circulation fan

3.1 Function

The installation of a packing gland on the drive shaft of the gas circulating fan prevents leakage of combustion gas from the fan housing.

The fan as originally built, was designed with a clearance hole in the housing at the drive shaft entry point. Since the fan was originally intended to continuously pump air, the designers considered that a small amount of leakage would be tolerable.

Such leakage is not tolerable for the use intended at DRES, since the long bags containing combustion gas will deflate under wind action if a leakage path is present.

3.2 Description of the packing gland

The packing gland is made up of three main parts, a body incorporating a stuffing box, anchor ring, to secure the body to the fan casing, and a gland compression sleeve, to squeeze the packing into the stuffing box and around the shaft. These elements are illustrated in the photographs numbered 3-1, 3-2, and 3-3.

The fan drive shaft is located at the center of the stuffing box. The original shaft was made from ordinary steel, and corrosion had developed on the surface. Since the fan is intended for outdoor use, the shaft was replaced with one made from stainless steel. This new shaft presents a smooth surface to the packing, which surface will not rust and become rough. The stainless shaft is shown attached to the fan impeller in photo number 3-4.

3.3 Packing

The packing is 3/8 inch square, braided, PTFE based material, Garlock style #5898, especially prepared for oxygen service. It is available in continuous coil form. It is the only Garlock packing suitable for oxygen service. Technical details are presented in appendix B.

Photograph 3-1
Stuffing box for
Fan shaft packing

Photograph 3-2
Anchor ring for
securing stuffing
box to fan casing

Photograph 3-3
Gland sleeve for
compressing packing
into stuffing box

Photograph 3-4
Fan impeller equipped with stainless steel shaft

3.4 Packing installation

The packing braid is cut off in a butt style configuration as shown in the manufacturers installation instructions given in appendix B, and is formed into rings.

For the rings to enter the stuffing box, the shaft bearings must be disassembled from their mounting plate, and the drive pulley removed. The rings can then be pressed home into the stuffing box, and around the shaft, using the aluminum installation sleeve shown in photograph 3-5.

This installation ring is then removed and the gland sleeve of photo 3-3 is entered first over the shaft, and next over the two threaded studs projecting from the stuffing box.

The packing is then brought into contact with the shaft using light wrench force on the gland draw-down nuts. A second nut on the stud tightened against the first, serves to prevent loosening.

The bearings are reassembled onto the mounting plate, their original positions being maintained by dowels drilled through the base. The inner races of the bearings are secured to the shaft with an eccentric clamp built into the bearing, and held with a set screw.

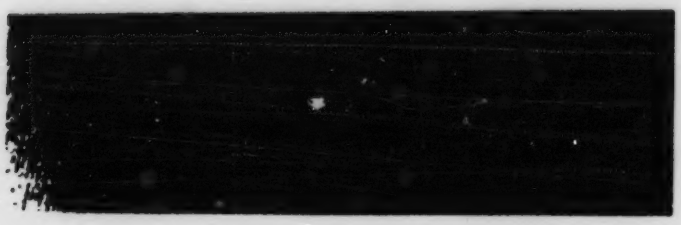
The pulley is then assembled on the shaft. Next the drive belt is installed and tensioned using the adjusting screw at the electric drive motor mount.

A shroud over the shaft is not used. This is to prevent the accumulation of combustible gas, which may occur under such a cover. In this way all leakage gas is vented off.

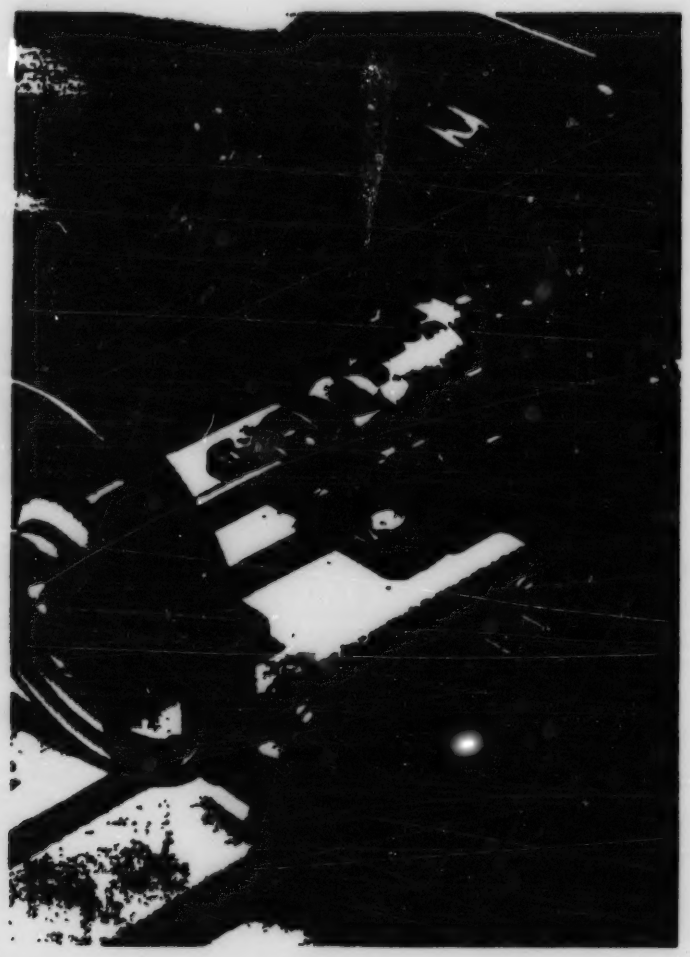
3.5 Adjustments

If the shaft is in contact with the stuffing box housing, or the gland is over-tightened, the unit will become hot when running.

Centering of the shaft in the stuffing box is accomplished by adjustment of the fan housing. For this the impeller is removed, allowing access to the internally located bolts securing the housing to the frame. The fan housing may be repositioned after loosening the mounting bolts. Reassembly is in the reverse order.



Photograph 3-5
Packing installation
sleeve



Photograph 3-6
Packing gland installation

After fan reassembly is completed, a running test is carried out to confirm that the adjustments have been correctly made.

If the stuffing box heats up quickly after start up, then immediate shut down is required followed by readjustment.

Correct adjustment is confirmed after prolonged running, by noting that the stuffing box runs cooler, than the electric driving motor. The stuffing box is shown under test in photograph 3-6.

4.0 Ramming system

4.1 Function

The function of the ramming system is to force the shot into a tapered feature in the gun bore, at the shot start position. The element of the shot offering resistance to forward movement is a copper driving band, which during this forcing action is deformed into the shape of the rifling. This action plugs the bore end of the powder chamber.

At ignition of the charge, the pressure in the powder chamber rises and the deformation of the copper band begins again. During a portion of the time that the pressure is rising, the shot does not move, and the chamber volume remains constant. This establishes stable burning of the propellant.

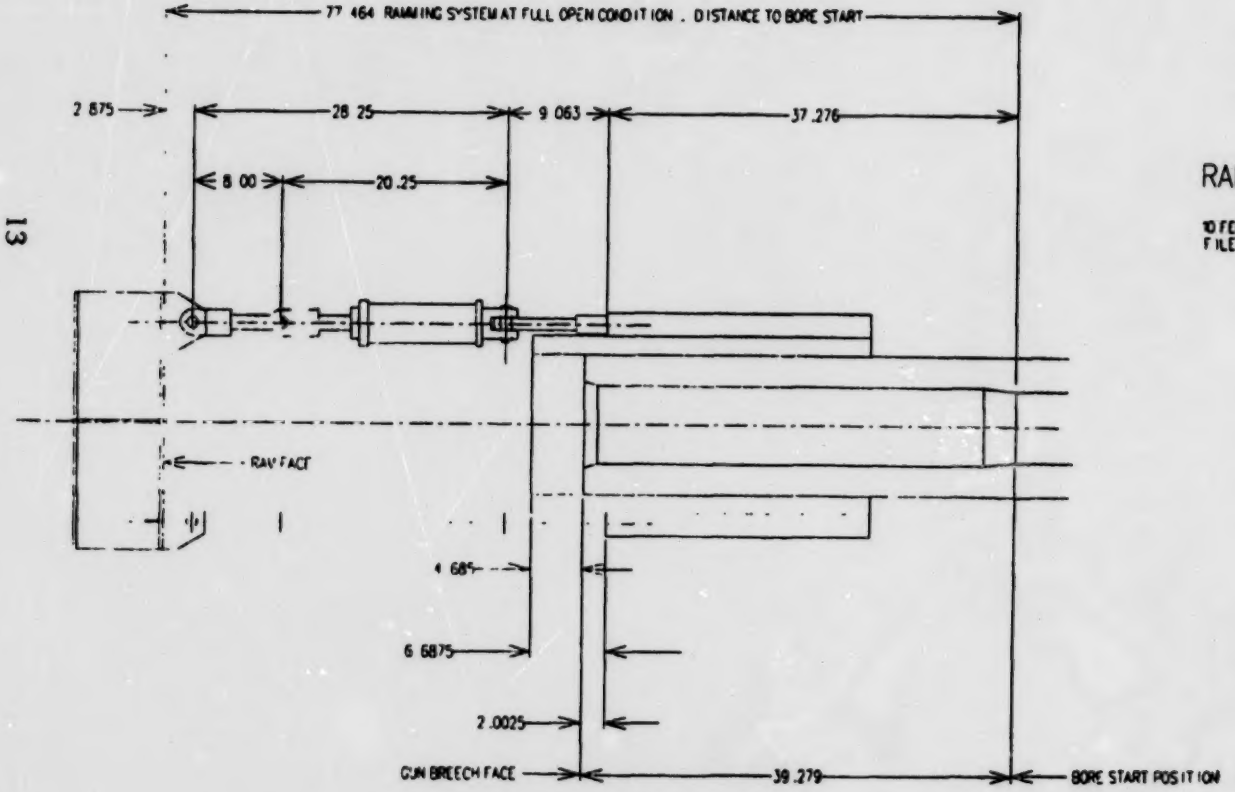
4.2 Ramming system description

The shot seating force is developed from two hydraulic cylinders attached to the breech end of the gun. Theses cylinders are arranged to pull a short beam towards the face of the breech. The configuration is shown on the drawing titled Ramming System Geometry, and in photograph 4-1.

As the beam is drawn towards the breech, it pushes against a long ram tube. The ram tube is held central to the gun bore by a pair of guides, which are a sliding fit in the powder chamber. One end of the ram tube slips into a sleeve at the beam center, and the other pushes against the base of the shot.

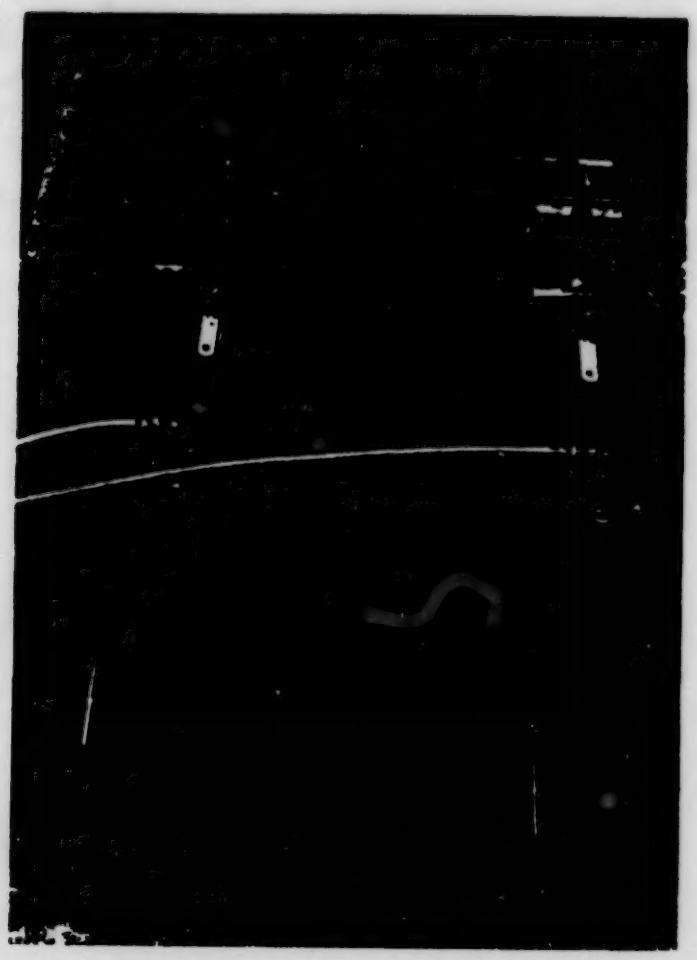
A number of heads can be fitted to the end of the ram tube to accommodate different shot base geometries.

The ram tube arrangement is shown in the drawing titled Ram Tube Layout.

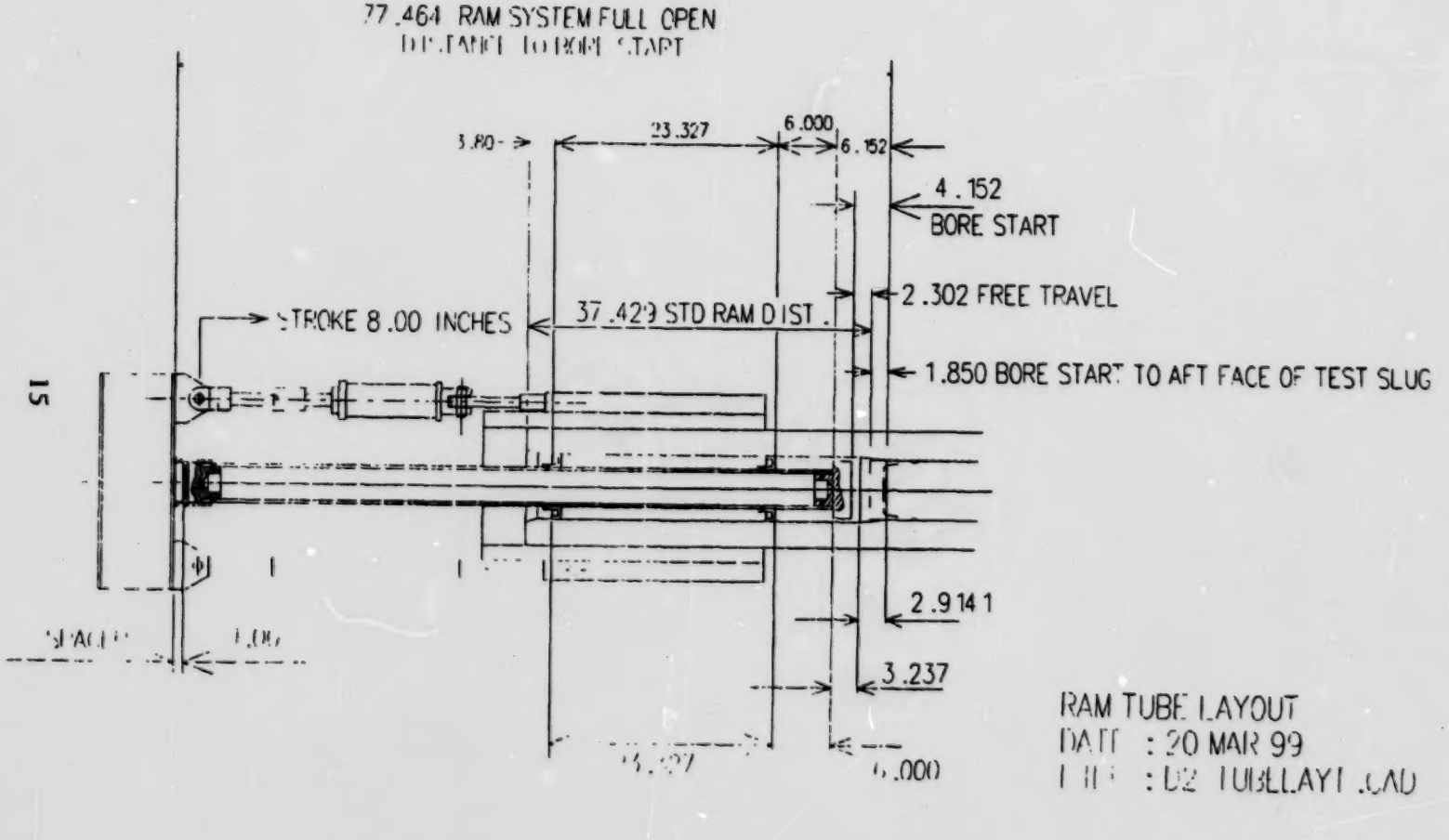


RAMMING SYSTEM GEOMETRY

10 FEB 90
FILE : 02 RAMSYDIM.CAD



Photograph 4-1 Ramming system. The long bolts shown in the foreground are used to attach the system to the breech end of the gun. The two hydraulic cylinders pull the crossbeam towards the gun. The sleeve at the center of the beam locates a long ram tube which extends into the gun and pushes the shot into position. Note the long pins permitting rapid removal of the beam. The black hoses are for high pressure hydraulic fluid. The yellow hose is for low pressure air used for rapid retraction of the ram.


77.464 RAM SYSTEM FULL OPEN
3.80
23.327
6.000
6.152
4.152
BORE START
2.302 FREE TRAVEL
STROKE 8.00 INCHES
37.429 STD RAM DIST.
1.850 BORE START TO AFT FACE OF TEST SLUG
2.9141
3.237
6.000
RAM TUBE LAYOUT
DATE : 20 MAR 99
FILE : D2 TUBELAYT.CAD

4.3 Ram system installation

4.3.1 Mechanical arrangements

The ram cylinders are each secured to the breech end of the gun using the lug assembly shown on the drawing bearing the same name. To attach the lugs, four of the breech ring bolts are unscrewed and removed. These are the two bolts straddling the vertical centerline at the top of the breech and the two bolts straddling the vertical centerline at the breech underside. A view of the upper lug position is given in the drawing titled Lug Layout, Rammer Mounting.

4.4 Rammer mounting

After installation of the lugs, the rammer mounting procedure is as follows:

1. Attach the lower cylinder to the lug using the pin provided in the cylinder clevis.

2. Place a prop under the free end of the cylinder so that the cylinder is horizontal.

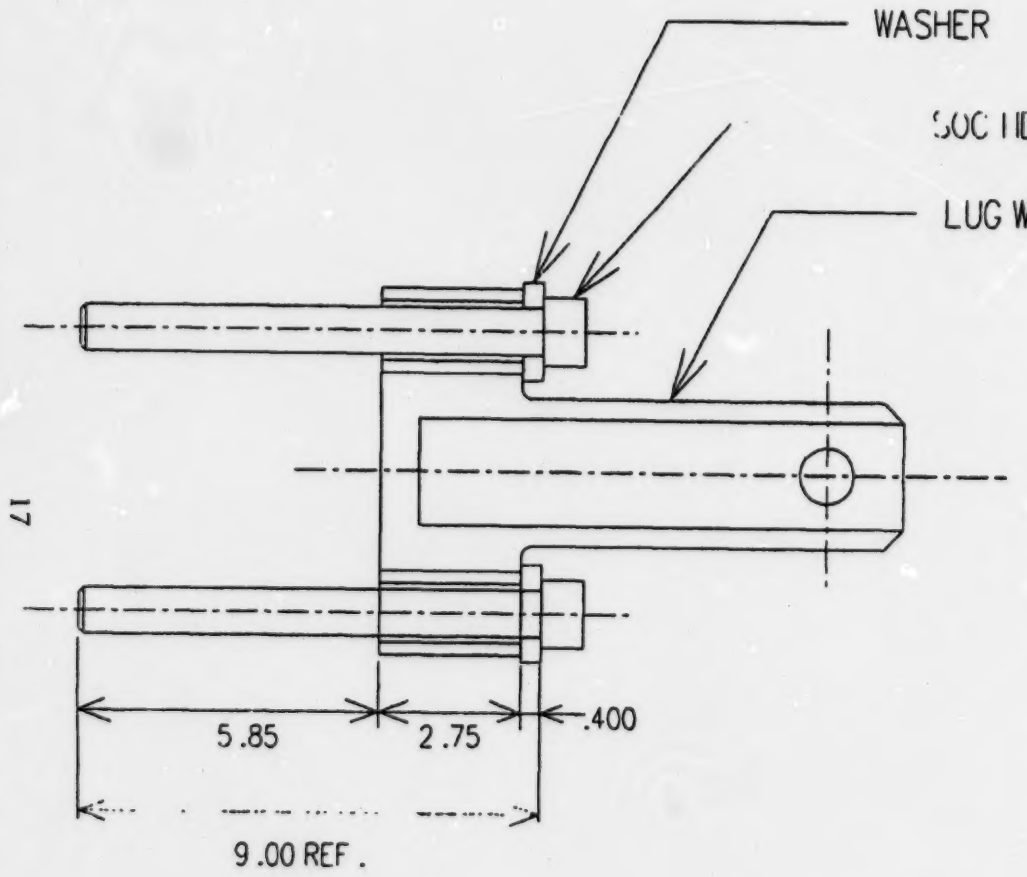
3. Place the ram tube into the bore and slide it forward into contact with the shot.

4. Attach the upper cylinder to the lug using the cylinder clevis pin.

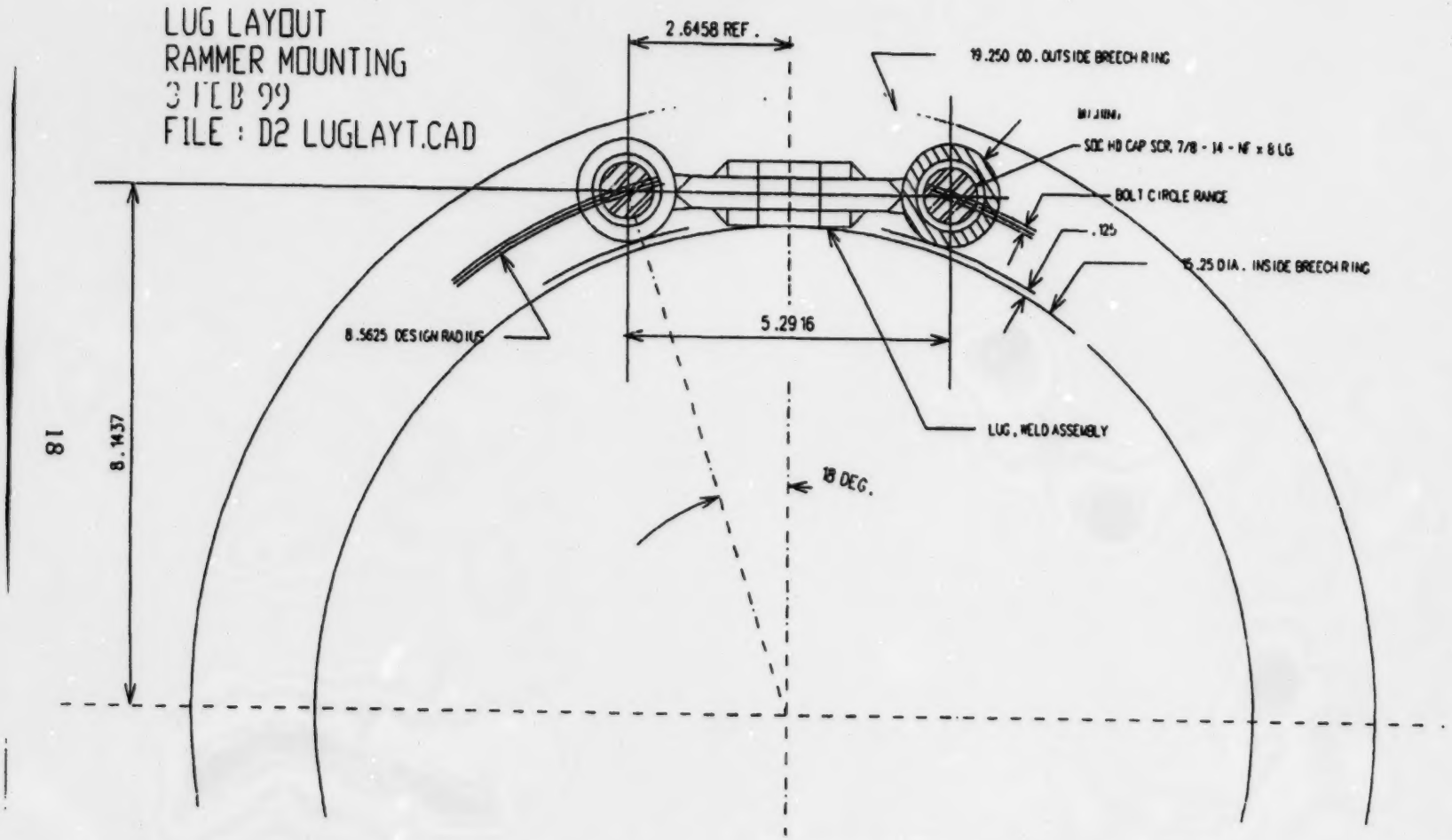
5. Connect the hydraulic hoses from the pump to the rod end of the cylinders. These connections are shown in photograph 4-2.

6. Connect a regulated 100 PSI air supply to the piston end of the cylinders. These connections are shown in photograph 4-3.

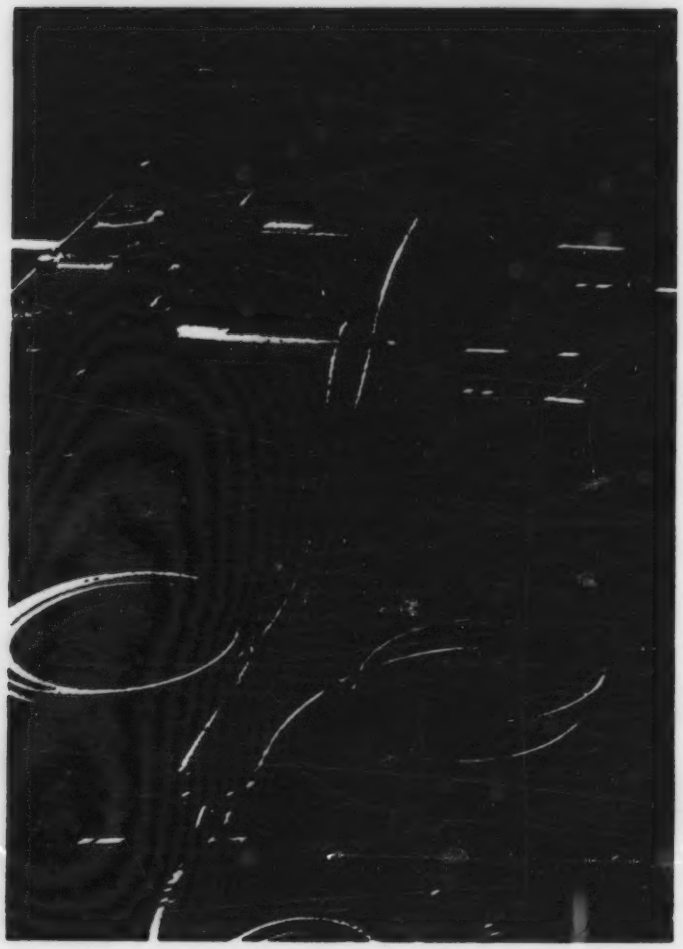
7. Using the pneumatic manifold, admit compressed air into the cylinders and extend the piston rods to the limit of their travel. Using the hydraulic manifold, route the surplus oil from the rod end of the cylinders into a portable reservoir. The pneumatic control manifold is shown in photograph number 4-4, and the hydraulic manifold in photograph 4-5.



LUG ASSEMBLY
4 FEB 99
FILE : D2 LUGASSY.CAD


LUG LAYOUT
RAMMER MOUNTING
3 FEB 99
FILE : D2 LUGLAYT.CAD
2.6458 REF.
19.250 OD. OUTSIDE BREECH RING
SOC HD CAP SCR, 7/8 - 14 - NF x 8 LG
BOLT CIRCLE RANGE
.125
15.25 DIA. INSIDE BREECH RING
8.5625 DESIGN RADIUS
5.2916
LUG, WELD ASSEMBLY
18 DEG.
8.1437
81

Photograph 4-2
Hydraulic connections to the ramming system



Photograph 4-3
Pneumatic connections to the ramming cylinders

Photograph 4-4 Pneumatic manifold
The compressed air supply line is the hose at the lower right. Note the shut off cock. The two hoses leading to the ram cylinders are in the background. The cock at the right vents the cylinders to atmosphere. A safety valve, at the left, protects the hose and equipment from over pressure.

Photograph 4-5 Hydraulic control manifold
The lower hose is the supply from a hand operated pump. The valves at the top control the flow to each cylinder. The valve in the right foreground is the vent control, returning the oil from the cylinders to a reservoir.

8. Hold the cross beam vertical, and advance it to engage the end of the ram tube.

9. Release the air pressure from the ram cylinders using the vent cock on the pneumatic manifold.

4.5 Ramming operations

1. Operate the hydraulic pump. This will retract the piston rods and drive the ram tube and the shot assembly forward in the gun bore.

2. If necessary, shut off the hydraulic supply to one cylinder for a short time while pumping, to insure that the cross beam remains in a vertical attitude.

3. When the driving band engages the seating position in the gun bore, the hydraulic pressure as indicated on the manifold gauge will rise, and at the same time forward motion will be reduced.

4. Note the pressure reading as the forward motion decreases.

5. Stop pumping when the pressure reaches 2500 PSI. Under this pressure the force developed by the ramming cylinders is as follows:

Bore of each cylinder	:	3.00 inches
Diameter of piston rod	:	1.25 inches
Area of bore	:	7.065 Sq. inches
Area of the rod	:	1.226 Sq. inches
Net gun bore area	:	28.837 Sq. inches

When ramming net area of the cylinder is 7.065 - 1.226 = 5.839 Sq. in.

Force developed in one cylinder = 2500 x 5.839 = 14,597.5 Lbs.

Force developed by two cylinders = 14,597.5 x 2 = 29,195 Lbs.

Projectile shot start pressure
as developed at ramming = 29,195 ÷ 28.837 = 1012 Lbs / Sq. in.

6. Measure the distance from the end of the ram tube to the breech face of the gun. This measurement locates the "as rammed" position of the shot in the bore. From this, the actual volume of the powder chamber will be determined. This is important since variations in the initial volume result in a change to muzzle velocity. Adjustments to the planned charge may then be made, depending upon the chamber volume obtained.

4.6 Disengagement of the ramming system

1. Open the vent valve of the hydraulic manifold. Make certain that the line from this valve is inserted into a portable reservoir.

2. With the pneumatic manifold, apply 100 PSI air pressure to the piston end of the ram cylinders. The cylinders will then extend, moving the ram away from the breech. If required, the needle valves of the hydraulic manifold can be used to regulate the speed and the distance of the ram retract motion.

3. Pull out the long pins to disconnect the cross-beam from the hydraulic cylinders.

4. Push out the pin securing the top cylinder to the mounting lug. Remove the cylinder and set it off to one side.

5. Remove the ram tube and set it off to one side.

6. Remove the lower cylinder in the same fashion as previously done for the top mounted cylinder.

7. Remove the rammer attachment lugs and recover the long bolts for future use.

8. Replace the four breech retaining bolts, and tighten them securely.

9. Check that all 20 breech retaining bolts are securely screwed home.

This ends the ramming procedure. The gun is now ready for installation of the firing circuit wiring in the powder chamber.

5.0 In-bore placement tools

5.1 Function

These tools facilitate the placement of test slugs and hollow flight bodies into the gun bore. The need for this arises from the long length of the powder chamber, which prevents direct manual handling of the shot assembly entering the bore.

5.2 Description

The device consists of a long wooden pole fitted with a "T"- handle at the near end, a rest near the middle, and an adaptor at the far end. The adaptor grips the base of the various projectiles which are to be inserted into the bore.

The gripping action is developed using a vacuum. Release after placement in the bore is easily accomplished remotely by disconnecting the vacuum.

The "T"- handle provides means for manipulation from outside the gun.

During loading operations, the rest lies in the powder chamber, bears on it's surface, and supports the pole in position near the gun centerline. The pole is eccentrically mounted in the rest. This provides the ability to shift the projectile up or down inside the gun simply by rotating the pole.

Swinging the handle slightly from side to side provides for adjustment of the projectile to the right or left, while entering the bore.

5.3 Loading

5.3.1 Hollow bodies

When placing hollow bodies into the gun bore it is necessary to rotate the round slightly so that the driving grooves enter the rifling.

Once entered, the hollow projectile is pushed short of it's start position. In this way contact with the pusher plate is obtained later, when ramming of the pusher is carried out.

It is essential that contact be established and maintained. In the early stages of launch, should a gap exist between these elements, the resulting impact could damage the hollow body.

5.3.2 Test slugs

Test slugs are entered into the bore more easily than hollow bodies, since they do not require prior engagement with the rifling, and do not need exact positioning, The ramming procedure described in the sections following, automatically seat test slugs at the shot start position.

The long pole arrangement with "T"- handle, rest, and adaptor, is illustrated in the diagram titled Engine Loading Tool.

5.4 Adaptors

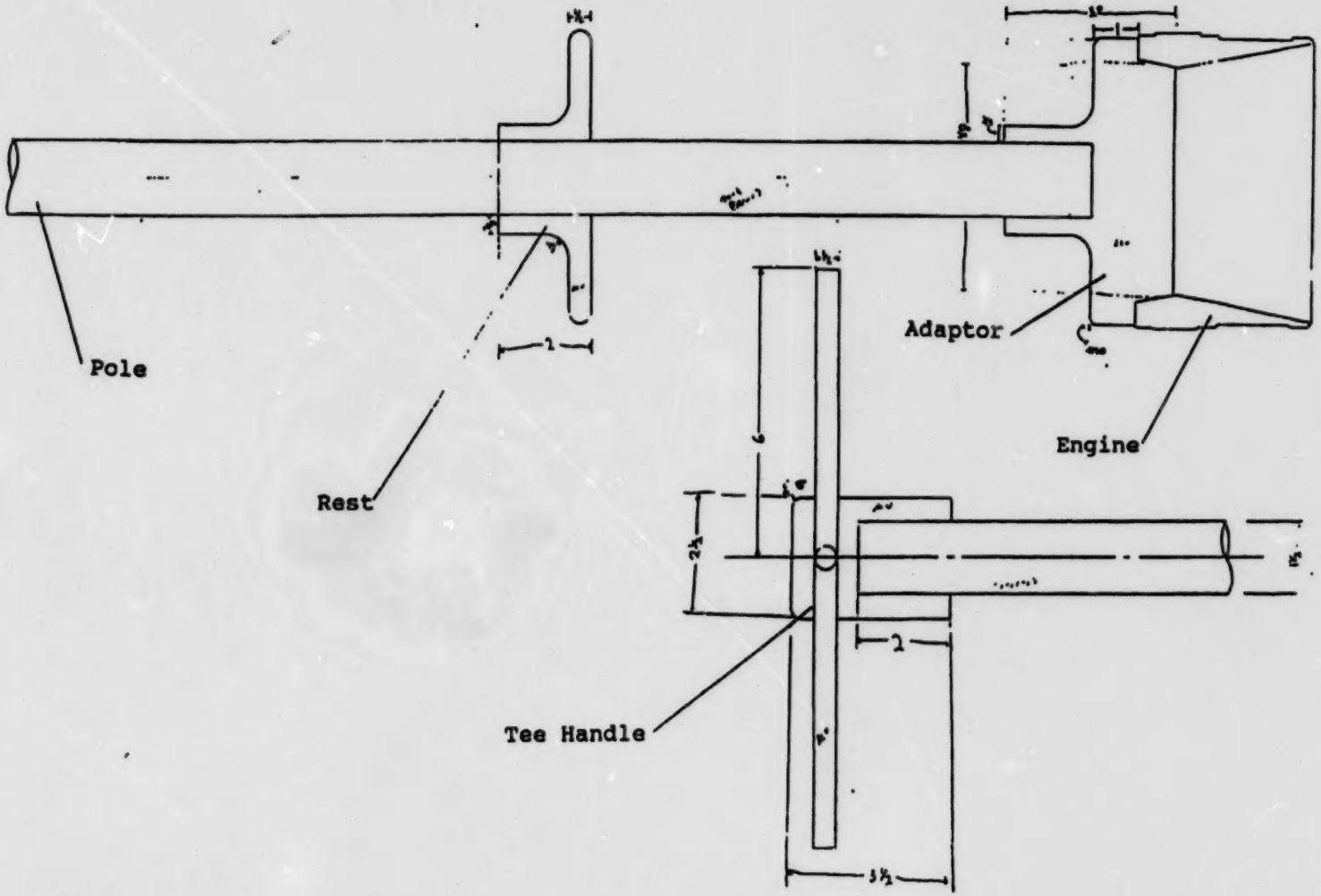
The adaptor assembly shown in the drawing bearing the same name is set up for placing hollow bodies in the bore. The O-rings (#6) and (#7) maintain a vacuum at the base end and inside of the hollow body. The vacuum line is connected at the pipe thread drawn at the lower left.

By removal of the center bolt, the forward section comes away, leaving the base, which is arranged for handling the test slugs.

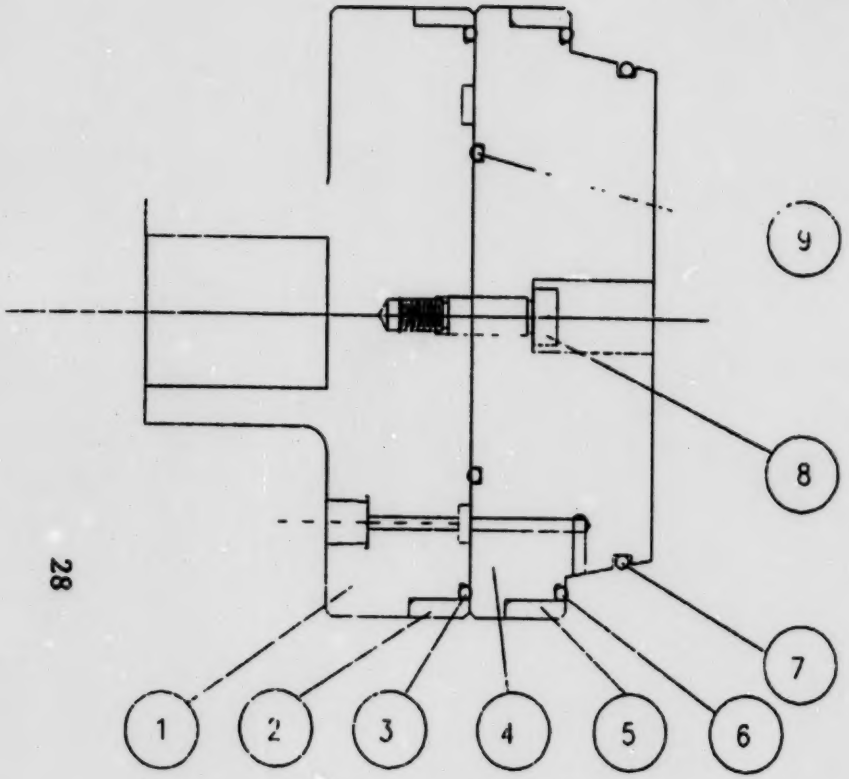
6.0 Pusher plate / sabot ramming procedure

The hollow projectile is a two part shot assembly, for which the loading and ramming procedure is summarized below:

1. Load the hollow body using the loading tool, and appropriate adaptor, with the vacuum retention feature to hold the projectile.



Engine Loading Tool



9 O-RING SEAL SIZE 234, BUNA N

8 SOC HD SHOULDER SCR 3/8 x 7/8 x 5/16 UNC

7 O RING SEAL SIZE 247, BUNA N

6 O-RING SEAL SIZE 252, BUNA N

5 RETAINER, O-RING

4 ADAPTOR, ENGINE FLIGHT BOBY

3 O-RING SEAL SIZE 252, BUNA N

2 RETAINER, O-RING

1 ADAPTOR, TEST SLUG

28

NOTE A. ITEMS 1, 2, & 3 USED ON TEST SLUGS

NOTE B. ITEMS 1 THROUGH 9 USED ON ENGINE FLIGHT BODIES.

ADAPTOR ASSEMBLY

23 DEC 98

D2 ADAPTASY.CAD

2. Rotate the body slightly so as to enter the rifling grooves, and once entered, stop all forward motion and disconnect the body from the loading tool.

3. If the body sticks to the O-rings, admit compressed air into the vacuum line to separate the projectile from the adaptor.

4. Withdraw the loading tools and set them to one side.

5. Attach the rammer outfit to the gun as described in section 4.0.

6. Fit the ram tube with the adaptor for the pusher plate and connect a vacuum line to the adaptor.

7. Offer the pusher plate to the adaptor and connect the line to the vacuum pump. The pusher plate will be held on the adaptor by the vacuum.

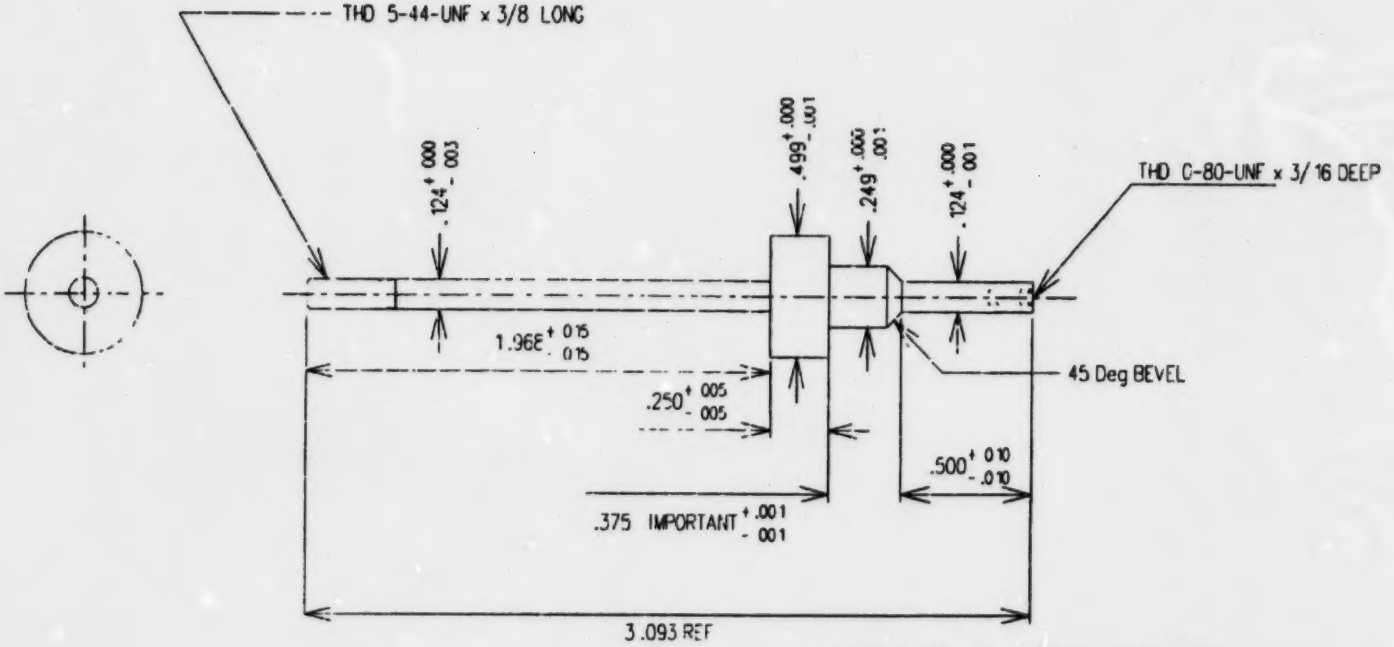
8. Slide the ram tube into the gun, (with the pusher plate attached), gently making contact with the hollow body, and without knocking the body forward.

9. Carry out the ramming procedure as outlined in section 4.0.

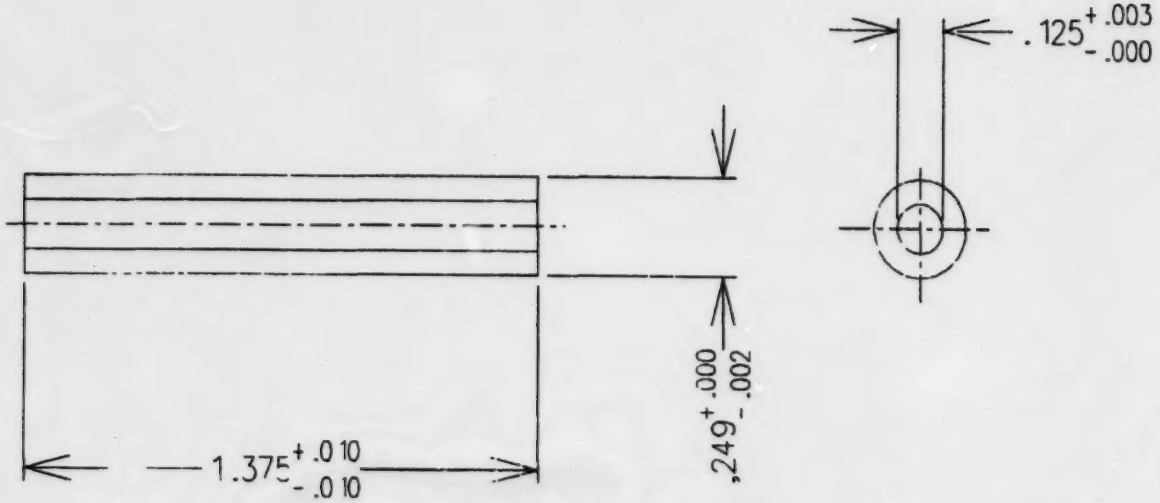
10. After recording the ramming pressure, and the ram distance, disconnect the vacuum source, and withdraw the ram system.

Appendix A

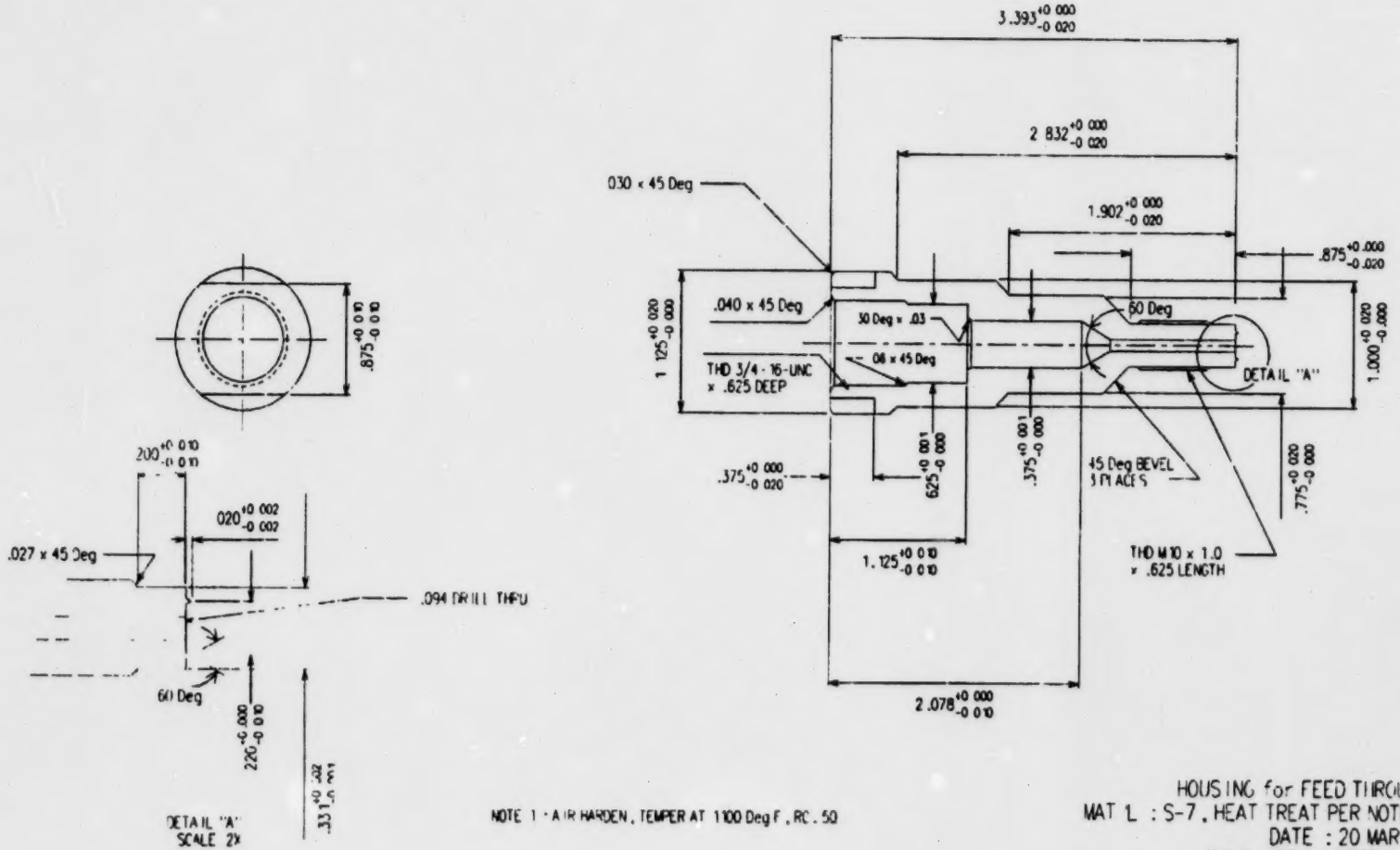
Details for Feed-Through unit



CONDUCTOR for FEED THROUGH
MAT 'L : AISI 1045, HEAT TREAT, HARDEN, OIL
QUENCH, TEMPER AT 1000 Deg F, BHN : 248
DATE : 20 MAR 99
FILE : D2 - CONDTFT .CAD

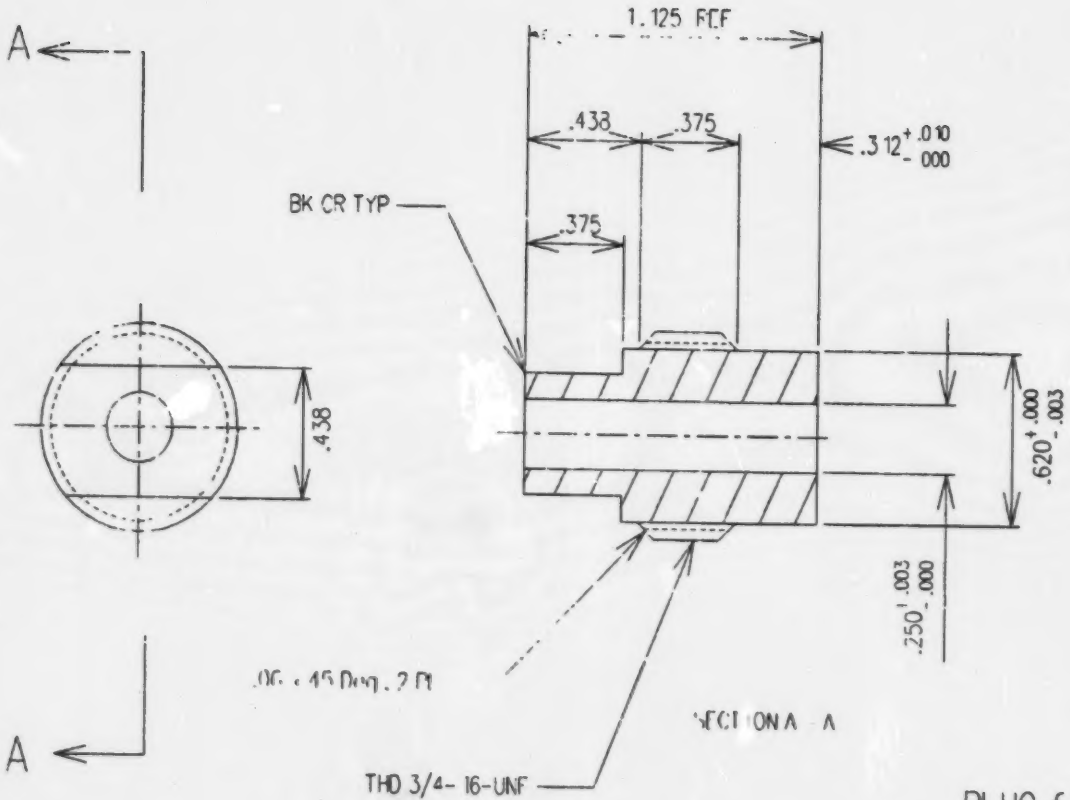


CONNECTOR SLEEVE
MAT 'L : LEXAN
DATE : 20 MAR 99
FILE : D2 - CONSLVFT .CAD



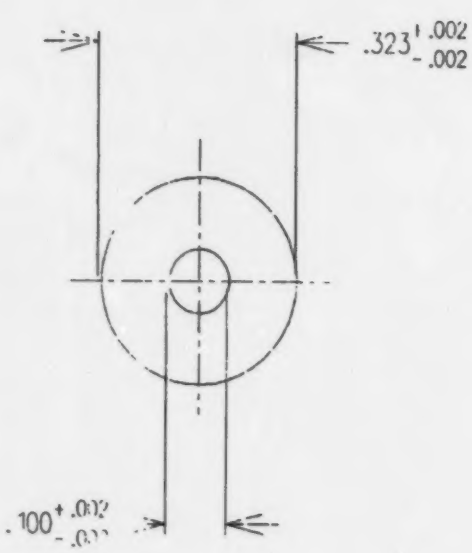
NOTE 1 - AIR HARDEN, TEMPER AT 1100 Deg F, RC. 50

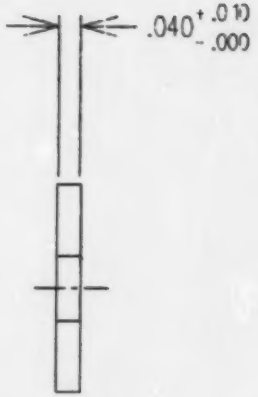
HOUSING for FEED THROUGH
MAT L : S-7, HEAT TREAT PER NOTE 1
DATE : 20 MAR 99
FILE : D2 - HSGFT .CAD



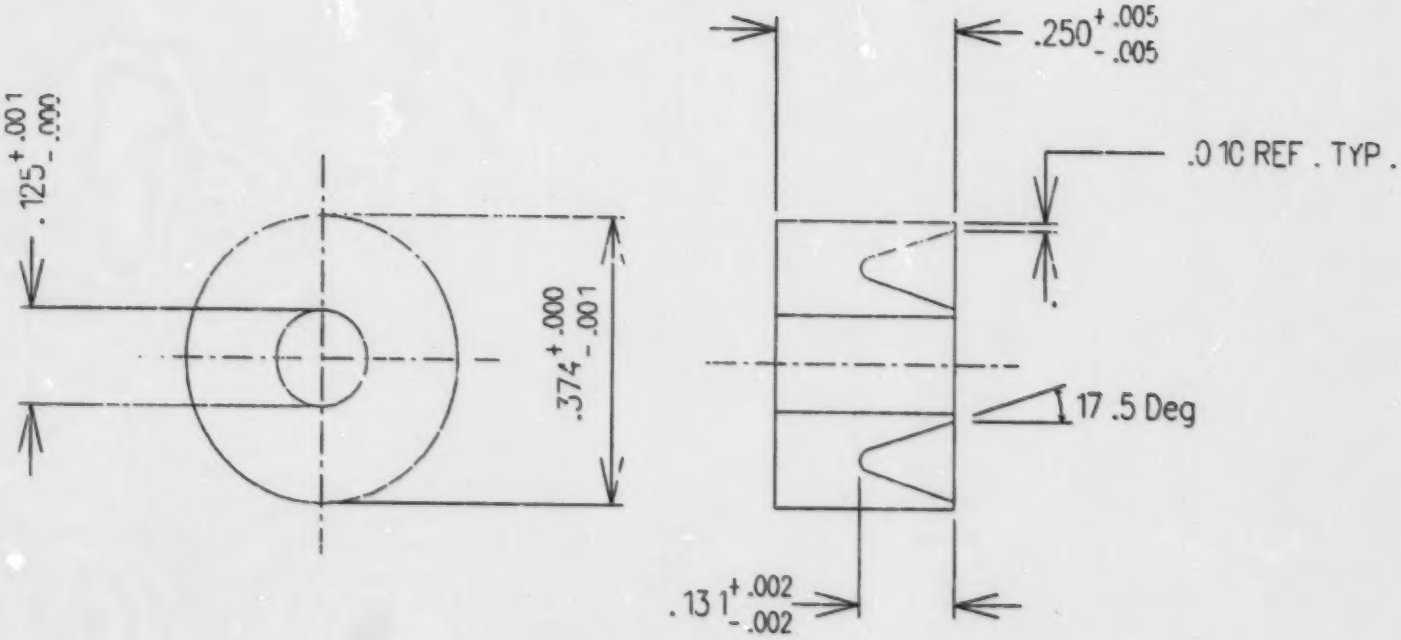
NOTE 1 : AIR HARDEN, TEMPER AT 1100 Deg F. RC : 50
NOTE 2 : TOLERANCES : .xxx = + / .005

PLUG for FEED THROUGH
MAT'L : S-7, HEAT TREAT PER NOTE 1
DATE : 20 MAR 99
FILE : D2 - PLUGFT .CAD

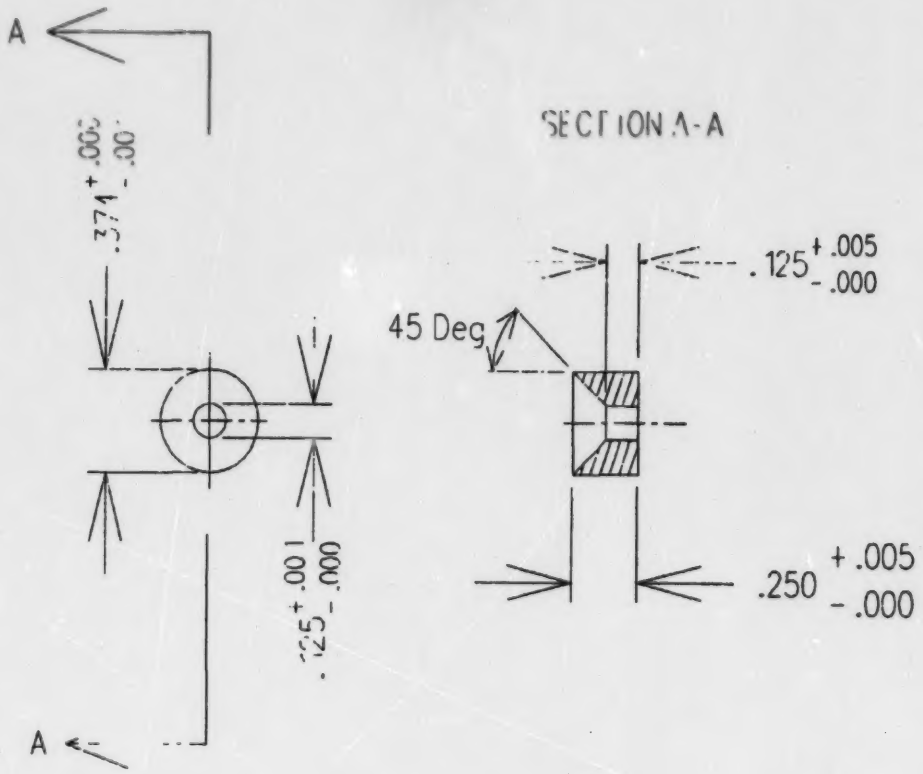




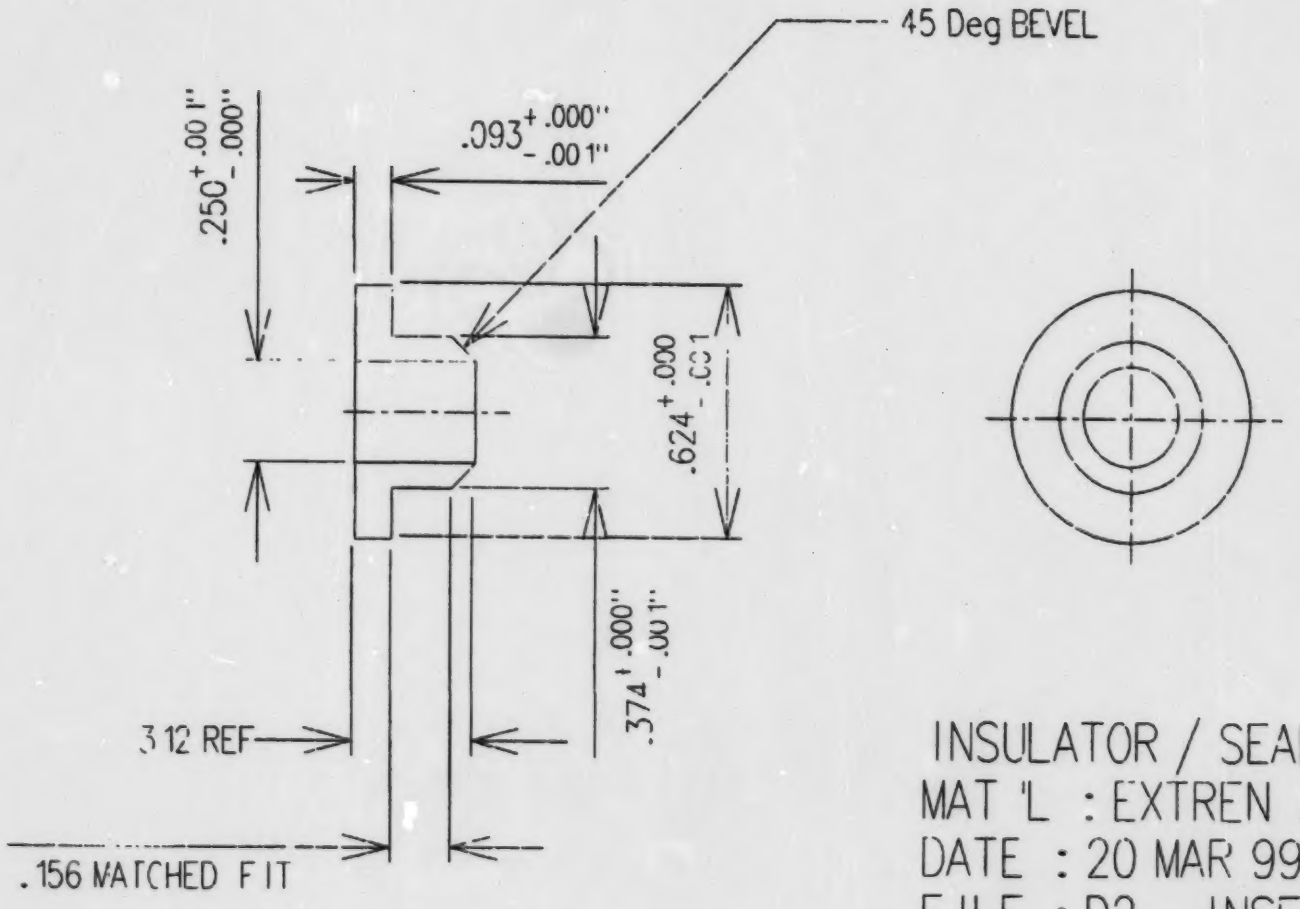
SEAL WASHER
MAT'L : COPPER, SOFT
DATE : 20 MAR 99
FILE : D2 - SEALWSFT.CAD



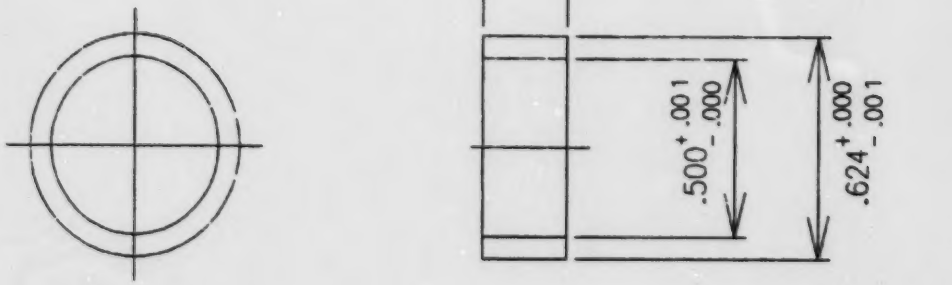
SEAL , FEED THROUGH
MATL : H.D.P.E.
DATE : 20 MAR 99
FILE : SEALFT .CAD



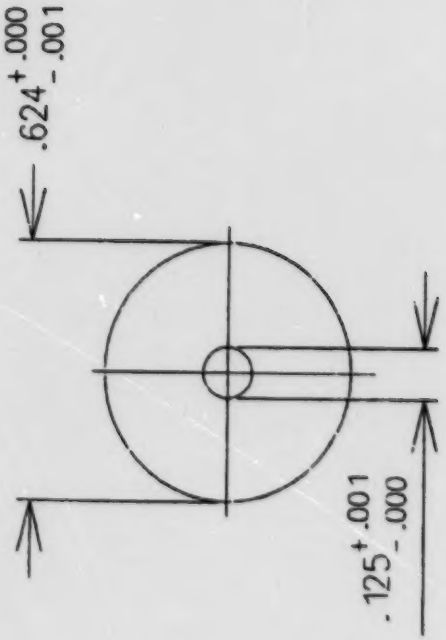
WEDGE
MAT'L : LEXAN
DATE : 20 MAR 99
FILE : D2-WEDGEFT.CAD



INSULATOR / SEAL
MAT 'L : EXTREN FIBREBOLT
DATE : 20 MAR 99
FILE : D2 - INSEALFT .CAD



INSULATOR / SLEEVE
MAT'L : EXTREN FIBREBOLT
DATE : 20 MAR 99
FILE : D2 - INSLVFT.CAD



LOAD BEARING WASHER
MAT'L : EXTREN FIBREBOLT
DATE : 20 MAR 99
FILE : D2 - LDERGWSR.CAD

Appendix B

Packing installation instructions

Packing technical data

INSTALLATION

INSTRUCTIONS

GARLOCK Sealing Technologies
Compression Packing Division
300 Alling Drive
Sodus, NY 14551-1091
Ph 800-472-4120/315-483-6961
Fax 800-525-6598/315-483-2378

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Rev. 12/96 INST:1C

Colfax Industries

Now that you have selected the proper packing for your application (if in doubt, contact your local GARLOCK Area Manager or our Technical Services' Application Engineer at Sodus) to attain maximum reliable service, it must be installed properly. The following instructions are industry accepted procedures as described in the Compression Packing Handbook sponsored by the members of the FLUID SEALING ASSOCIATION.

PACKING THE PUMP CORRECTLY

The importance of packing the pump correctly cannot be overemphasized. Many packing failures are due to incorrect installation of the packing. The following steps have been devised to ensure effective installation of packings in pumps.

1. REMOVE ALL OF THE OLD PACKING FROM THE STUFFING BOX. Clean box and shaft thoroughly and examine shaft or sleeve for wear and scoring. Replace shaft or sleeve if wear is excessive.

2. USE THE CORRECT CROSS-SECTION OF PACKING OR DIE-FORMED RINGS. To determine the correct packing size, measure the diameter of the shaft (inside the stuffing box area, if possible) and then stuffing box (to give the OD of the ring). Subtract the ID measurement from the OD measurement and divide by two. The result is the required packing size.

CUT - DON'T WIND

3 WHEN USING COIL OR SPIRAL PACKING, ALWAYS CUT THE PACKING INTO SEPARATE RINGS. Never wind a coil of packing into a stuffing box. Rings can be cut with butt (square), bias or diagonal joints, depending on the method used for cutting. The following illustration shows these methods of preparing bulk packing. The best way to cut packing rings is to cut them on a mandrel with the same diameter as the shaft in the stuffing box area. If there is no shaft wear, rings can be cut on the shaft outside the stuffing box.

Hold the packing tightly on the mandrel, but do not stretch excessively. Cut the ring and insert it into the stuffing box, making certain it fits the packing space properly. Each additional rin-

manner, or the first ring can be used as a master from which the balance of the rings are cut.

If the butt cut rings are cut on a flat surface, be certain that the side of the master rings, and not the OD or ID surface, is laid on the rings to be cut. This is necessary so that the end of the rings can be reproduced.

When cutting diagonal joints, use a maple mitre board so that each successive ring can be cut at the correct angle.

It is necessary that the rings be cut to the correct size. Otherwise, service life is reduced. This is where die-cut rings are of great advantage, as they give you the exact size ring for the ID of the shaft and the OD at the stuffing box. There is no waste due to incorrectly cut rings.

4 INSTALL ONE RING AT A TIME. Make sure it is clean, and has not picked up any dirt in handling. If desired, lubricate the shaft

Seat rings firmly (except PTFE filament and graphite yarn packings, which should be snugged up very gently, then tightened gradually after the pump is on stream). Joints of successive rings should be staggered and kept at least 90° apart. Each individual ring should be firmly seated with a tamping tool When enough rings have been individually seated so that the nose of the gland will reach them, individual tamping should be supplemented by the gland.

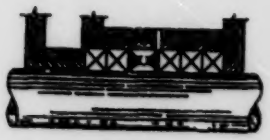
5 AFTER THE LAST RING IS INSTALLED, take up bolts finger-tight or very slightly snugged up. Do not jam the packing into place by excessive gland loading. Start pump, and take up bolts until leakage is decreased to a tolerable minimum. Make sure gland bolts are taken up evenly.

STOPPING LEAKAGE ENTIRELY AT THIS POINT WILL CAUSE THE PACKING TO BURN UP.

6. ALLOW THE PACKING TO LEAK FREELY WHEN STARTING UP A NEWLY PACKED PUMP. Excessive leakage during the first hour of operation will result in a better packing life over a longer period of time. Take up gradually on the gland as the packing seats, until leakage is reduced to a tolerable level.

NEVER TRY TO STOP LEAKAGE ENTIRELY, UNLESS PACKING MANUFACTURER INDICATES THAT IT IS SAFE TO DO SO.

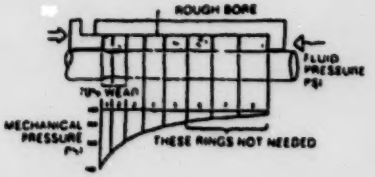
7. WHEN SPECIFIED BY THE PUMP MANUFACTURER, PROVIDE MEANS OF LUBRICATING THE SHAFT AND PACKING THROUGH THE LANTERN RING BY SUPPLYING WATER, OIL, GREASE, OR LIQUID HANDLED IN THE PUMP. Fittings for this purpose are standard on many pumps.



8 IF THE STUFFING BOX HAS A LANTERN RING (see illustration above), make sure that the lantern ring, as installed, is slightly behind the fluid inlet so that it will move under the inlet as follower pressure is applied.

9. REPLACE PACKING WHEN LEAKAGE CANNOT BE CONTROLLED BY FURTHER TAKE-UP ON THE FOLLOWER GLAND.

10. ON BOTH CENTRIFUGAL AND RECIPROCATING PUMPS, about 70% of wear is on the outer two packing rings nearest the gland. However, each additional ring does throttle some fluid pressure.

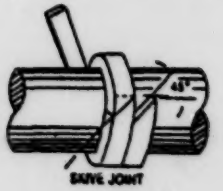


The mechanical pressure curve above shows eight packing rings. The first five rings do the majority of the sealing. The bottom three do little sealing, but are needed to fill the available space. The advantage of using fewer rings is less rod wear. Also, the stuffing box design is simpler and takes less material. But, wear isn't the only problem. With high temperatures, high pressures, corrosive chemicals, or abrasive particles in the fluid, more rings may be the only solution for some services. In such cases, the bottom ring contacting the fluid may have the most wear from these severe service conditions.

PACKING VALVES CORRECTLY

As with pump packing, the first step in getting the most out of a valve packing is correct installation. Here is the correct way to pack valves.

1. CAREFULLY PERFORM ALL OPERATIONS LISTED UNDER PUMP PACKING, STEPS 1 - 5. Rings used on valves and expansion joints are generally cut with a diagonal joint (illustrated below). In preparing diagonal cut (45°) rings, be sure that the first ring is cut carefully, and then tested on the stem.



2. BRING THE FOLLOWER DOWN ON THE PACKING TO THE POINT WHERE HEAVY RESISTANCE TO WRENCHING IS FELT. During this time, turn valve stem back and forth to determine ease of turning. Do not torque down to the point where the stem won't turn

3. AFTER THE VALVE HAS BEEN ON THE LINE A DAY OR SO, EVEN IF NO LEAKAGE EXISTS, THE FOLLOWER SHOULD BE TIGHTENED SLIGHTLY. Obviously, if leakage is occurring, the follower must be tightened.

Garlock Sealing Technologies

300 Alling Dr.
Sodus, NY 14551
(800) 472-4120 (ext. 3946)
Fax: (800) 525-6599

FAX TRANSMISSION COVER SHEET

To: MR DAVID WEISS Date: 1-14-98

Company: BROME LABORATORIES

Fax: (450) 263-6903

Re: 5898 Data Sheet

Sender: Christopher S. Boss

YOU SHOULD RECEIVE 2 PAGE(S), INCLUDING THIS COVER SHEET. IF YOU DO NOT RECEIVE ALL THE PAGES, PLEASE CALL (800) 472-4120 (ext. 3946).

Attached is the product data sheet that you requested for our style 5898

If you should have any questions, please feel free to call me at the number above

Regards,

C. Boss

Christopher S. Boss
Applications Engineer

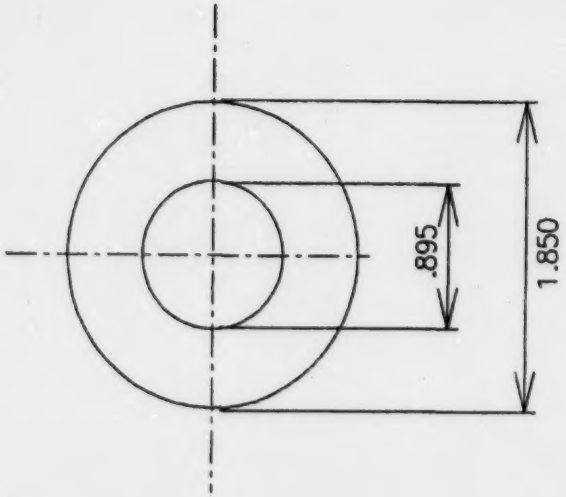
STYLE #5898

A continuous filament PTFE yarn packing that is specially treated for superior leakage control in gaseous and liquid oxygen service. PTFE dispersion keeps friction low while minimizing through-the-braid seepage. It is pre-shrunk for dimensional stability, forming a dense, firm packing. Style #5898 is often specified for use on reciprocating rods, rams, and plungers, agitators, check and needle valve stems, and safety injection system valves.

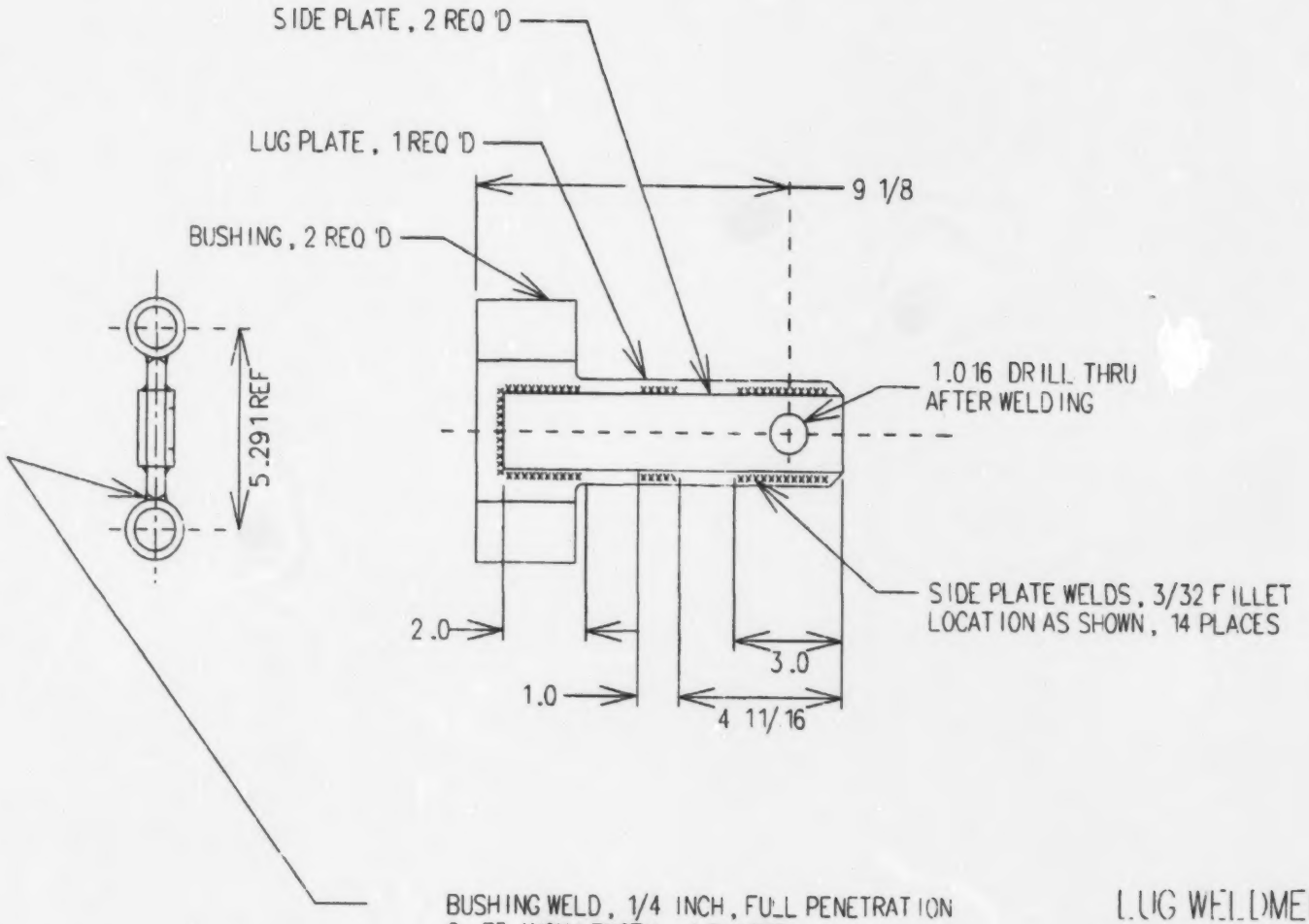
TEMPERATURE	-450°F(-268°C) to +500°F(+260°C)
PH RANGE	0 - 14
SHAFT SPEED	To 1000 fpm Plus
PRESSURE	To 300 psi (Rotary/Centrifugal)
CONSTRUCTION	LATTICE BRAID®

Appendix C

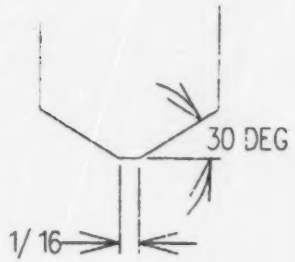
Details for ramming system



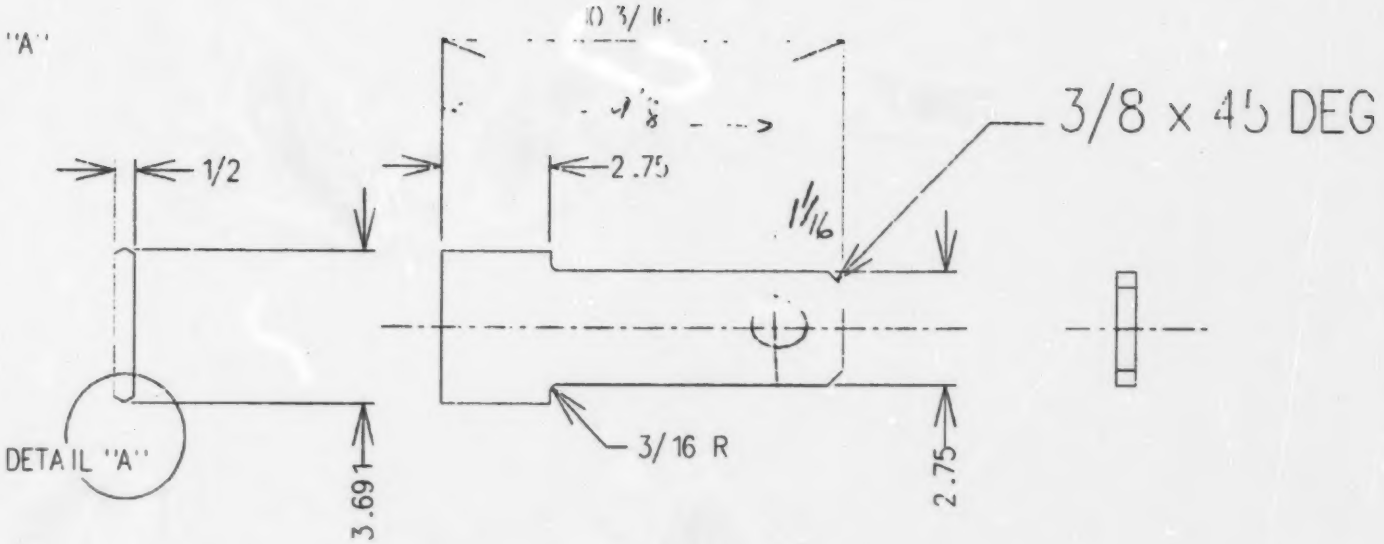
WASHER
MAT'L : A-36
4 FEB 99
FILE : D2 WASHER .CAD



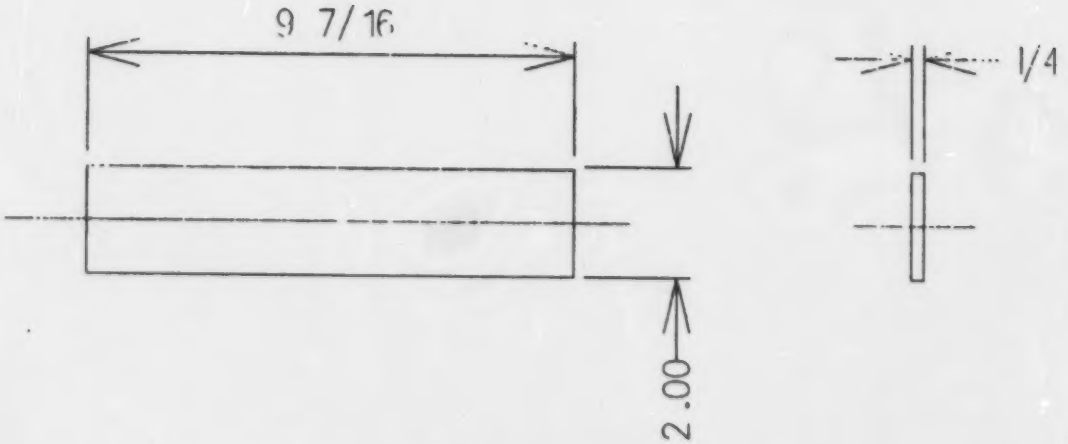
LUG WELDMENT
6 FEB 99
FILE : D2 LUGWELD .CAD



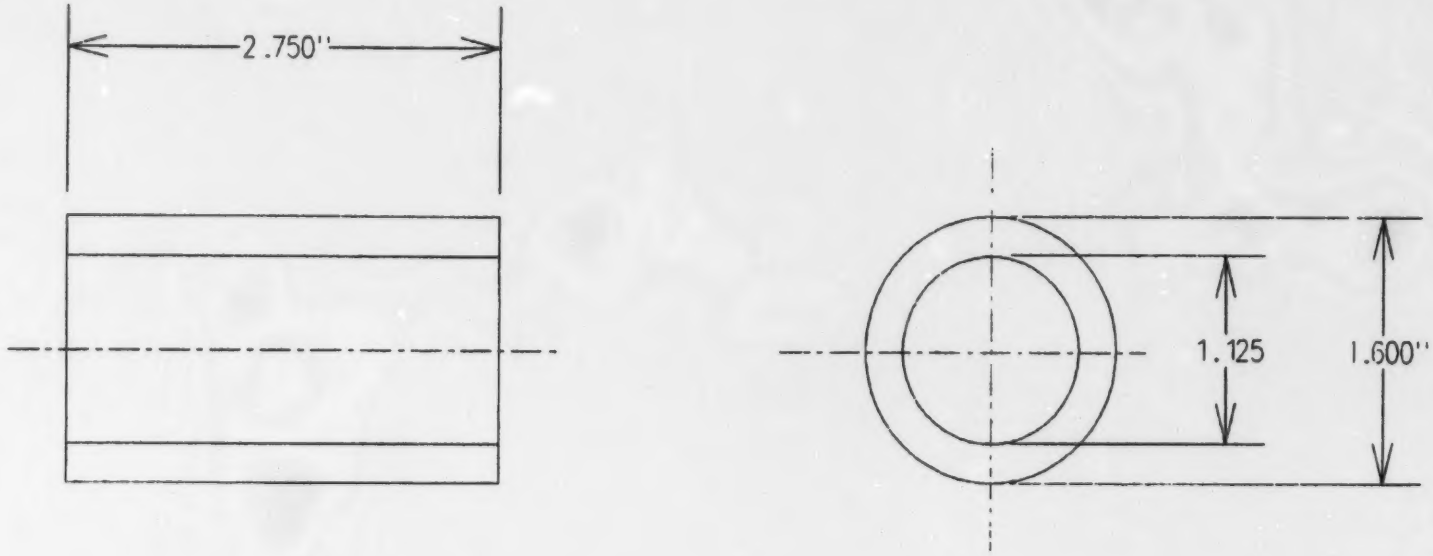
DETAIL "A"



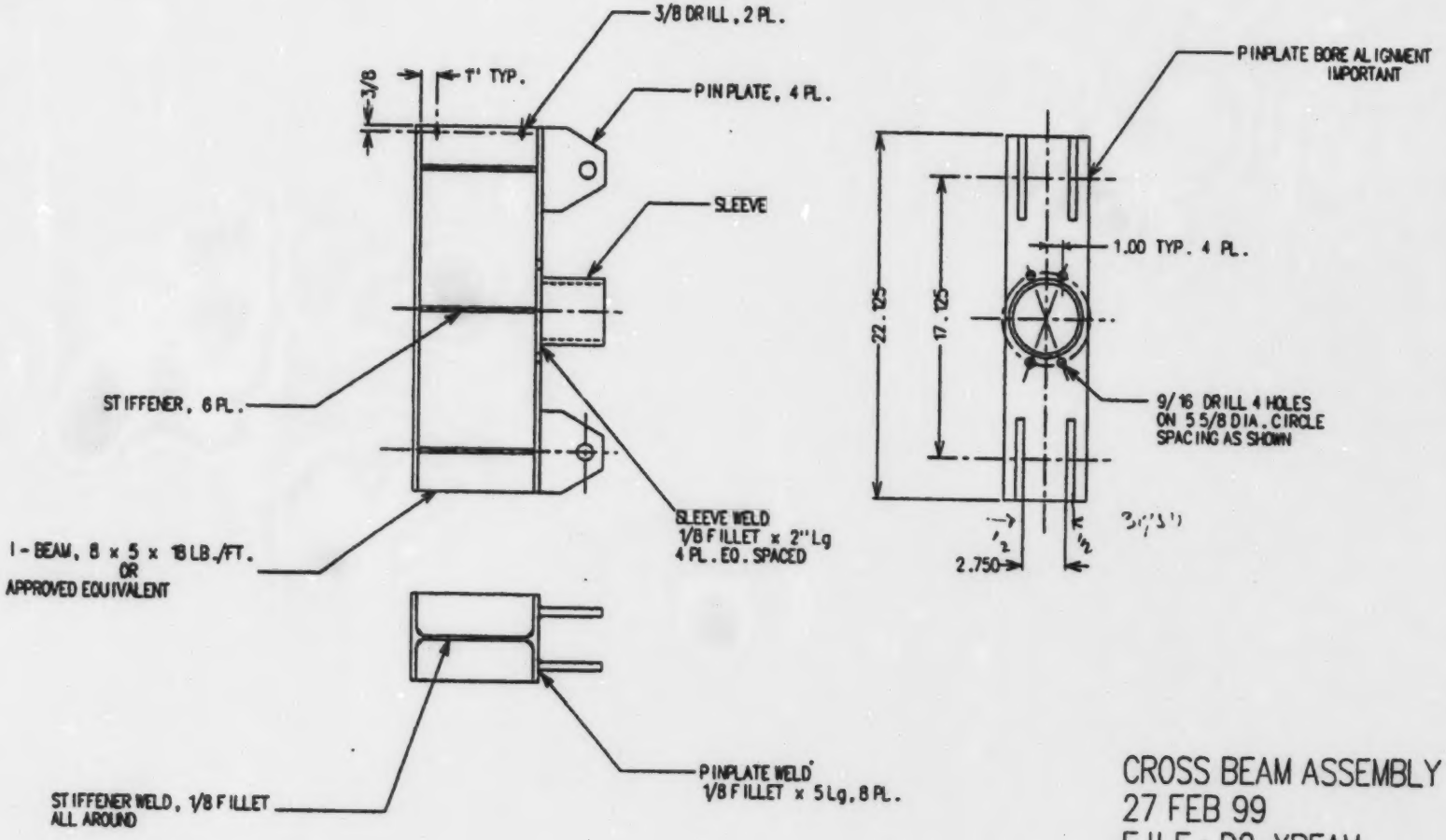
LUG PLATE
MAT'L : A-36
5 FEB 99
FILE : D2 LUGPLATE .CAD



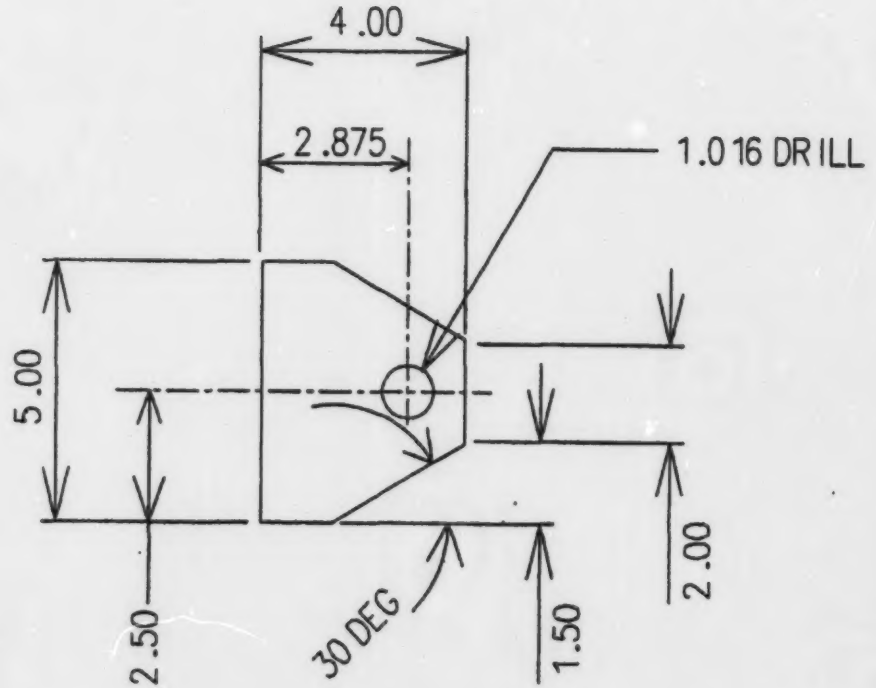
SIDE PLATE
MAT'L : A-36
5 FEB 99
FILE : D2 SIDEPL .CAD

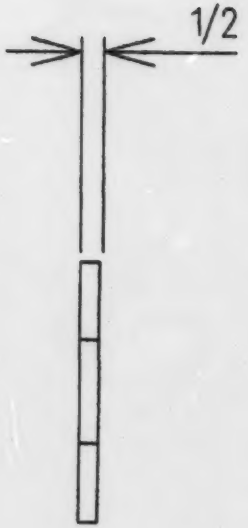


BUSHING
MATL : A .56
4 FEB 99
FILE : D2 BUSHING .CAD

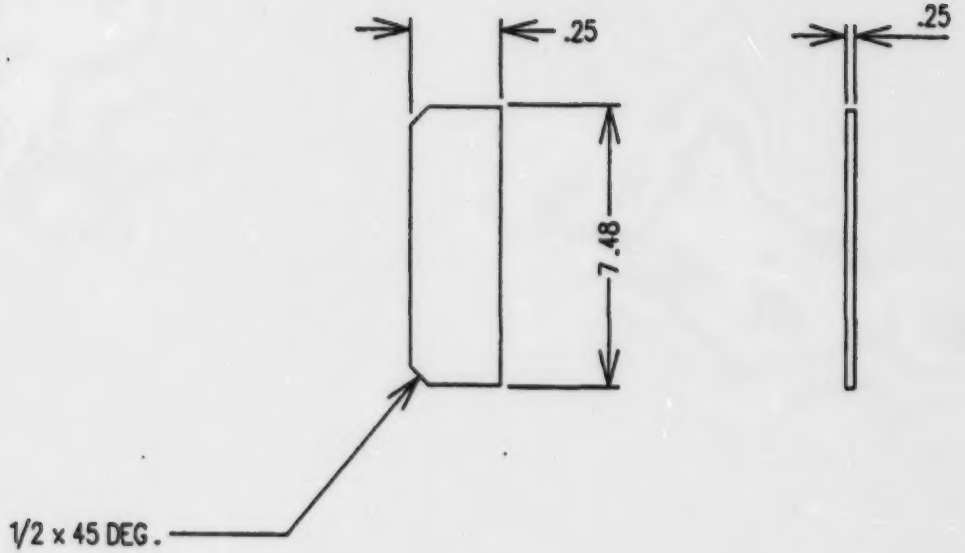


CROSS BEAM ASSEMBLY
27 FEB 99
FILE : D2-XBEAM

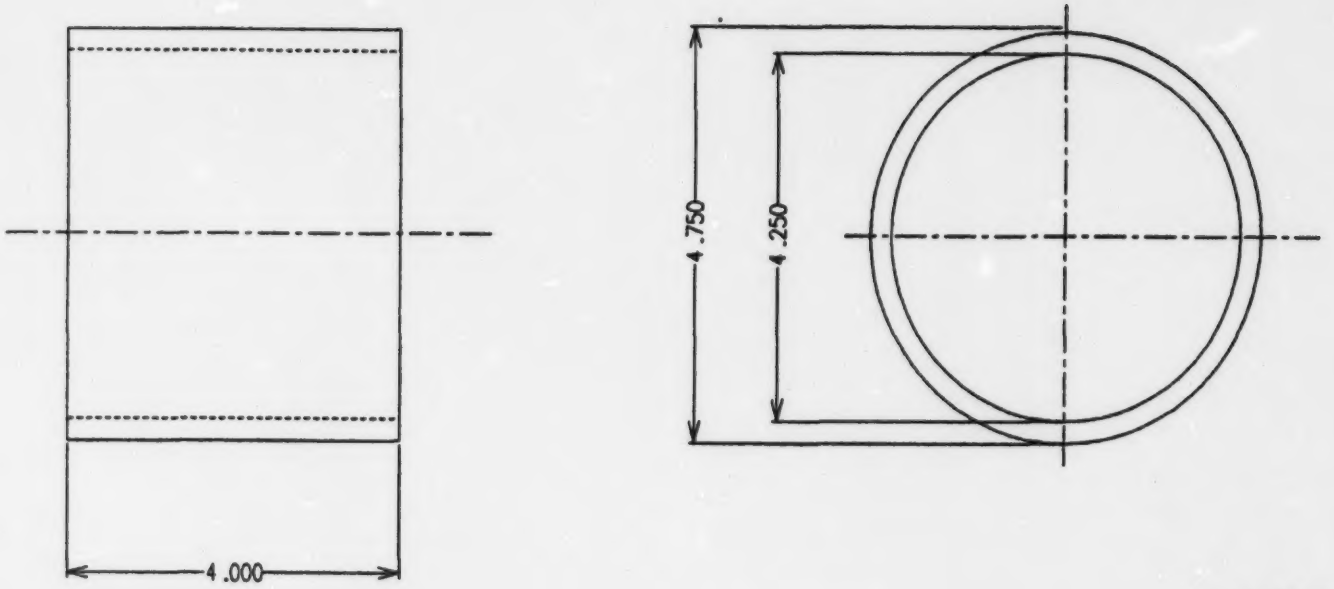




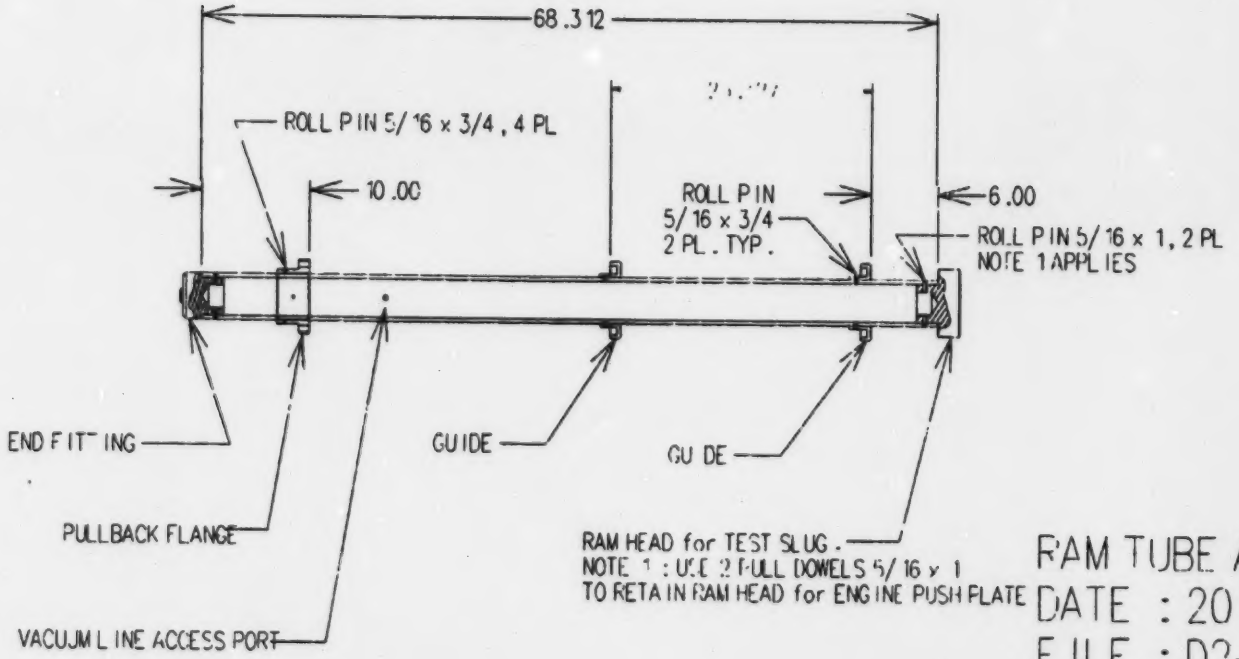
PIN PLATE
MAT'L : A-36
8 FEB 99
FILE : D2 PINPLATE.CAD



STIFFENER
MAT'L : A-36
8 FEB 99
FILE : D2 STIFFNER.CAD



SLEEVE
MAT'L : AISI 1020
27 FEB 99
FILE : D2 - SLEEVE .CAD

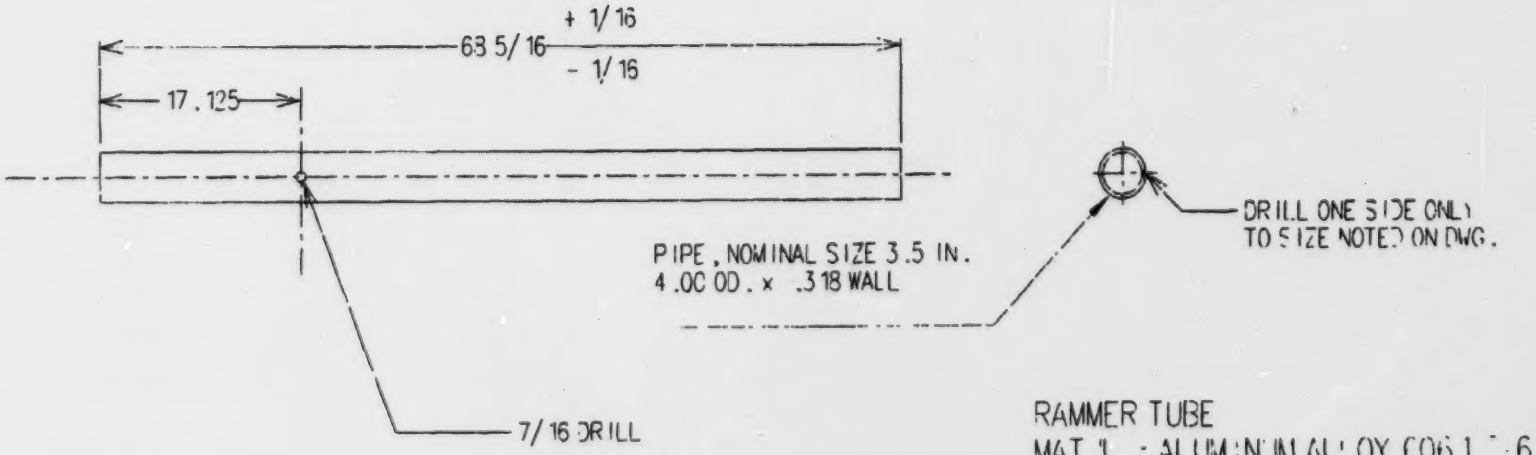


RAM TUBE ASSY
DATE : 20 MAR 99
FILE : D2-TUBEASSY CAD

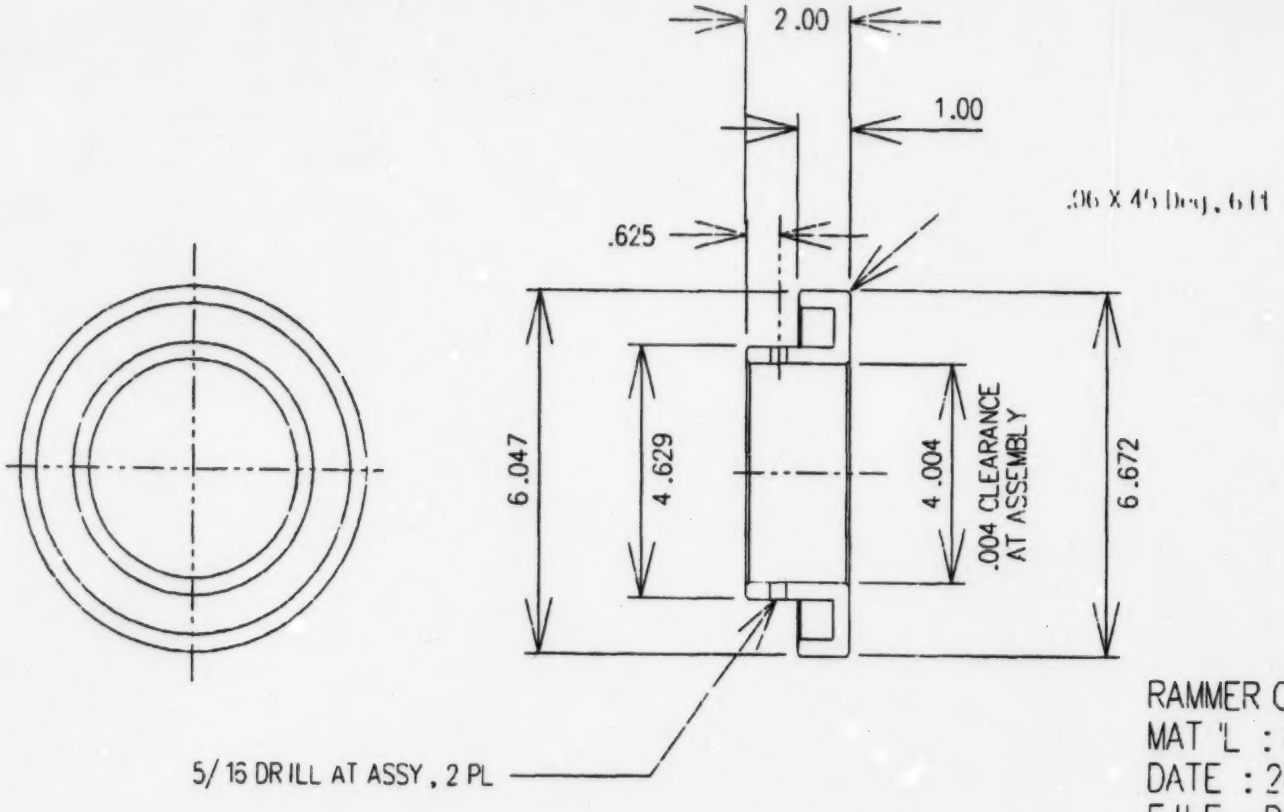
NOTE 1 : REMOVE BURRS AND MARKS
FROM EXTERIOR SURFACE

NOTE 2 : REMOVE BURRS FROM INTERIOR FOR A
DISTANCE OF 2.5 INCHES, EACH END.

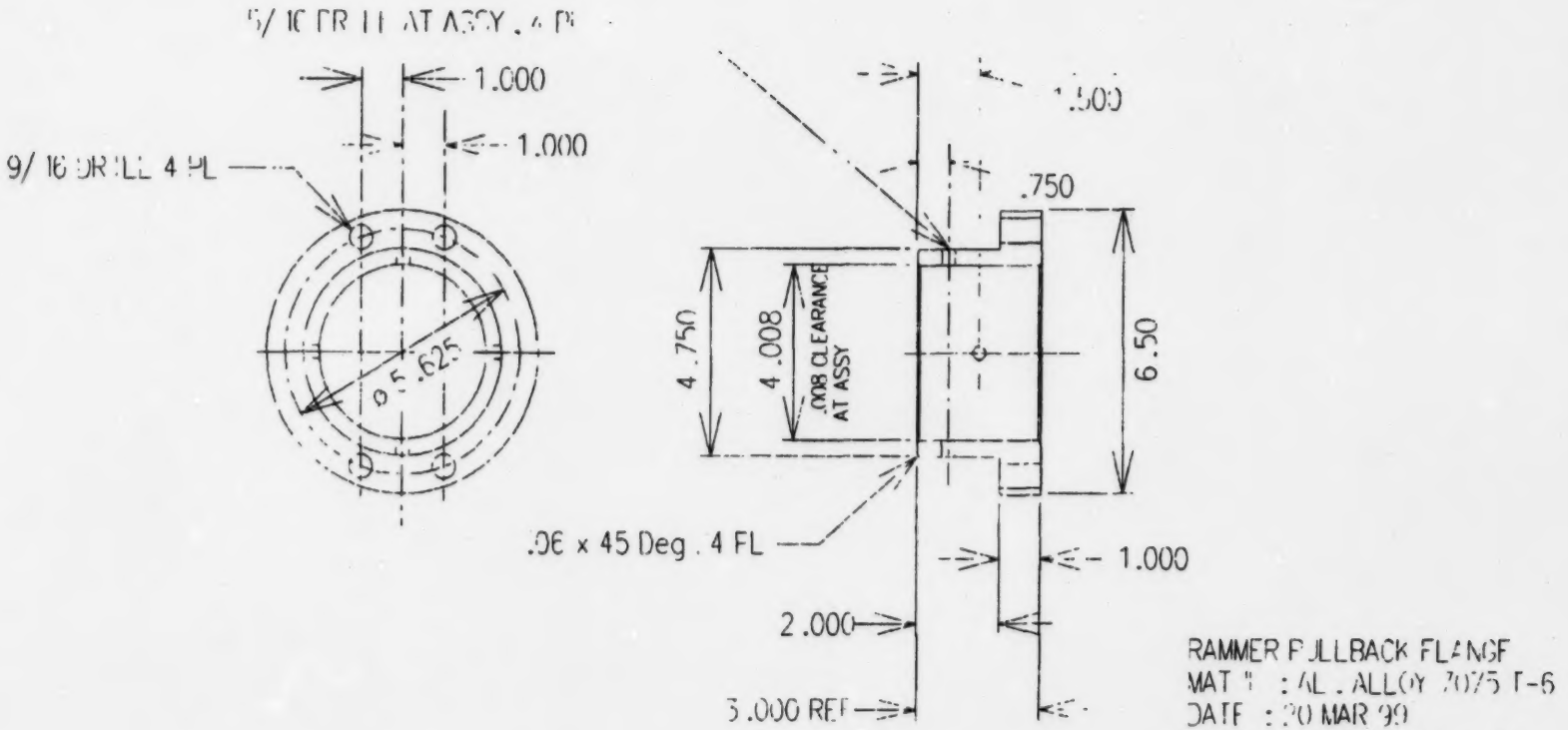
NOTE 3 : ENDS TO BE TURNED SQUARE
TO CENTERLINE.



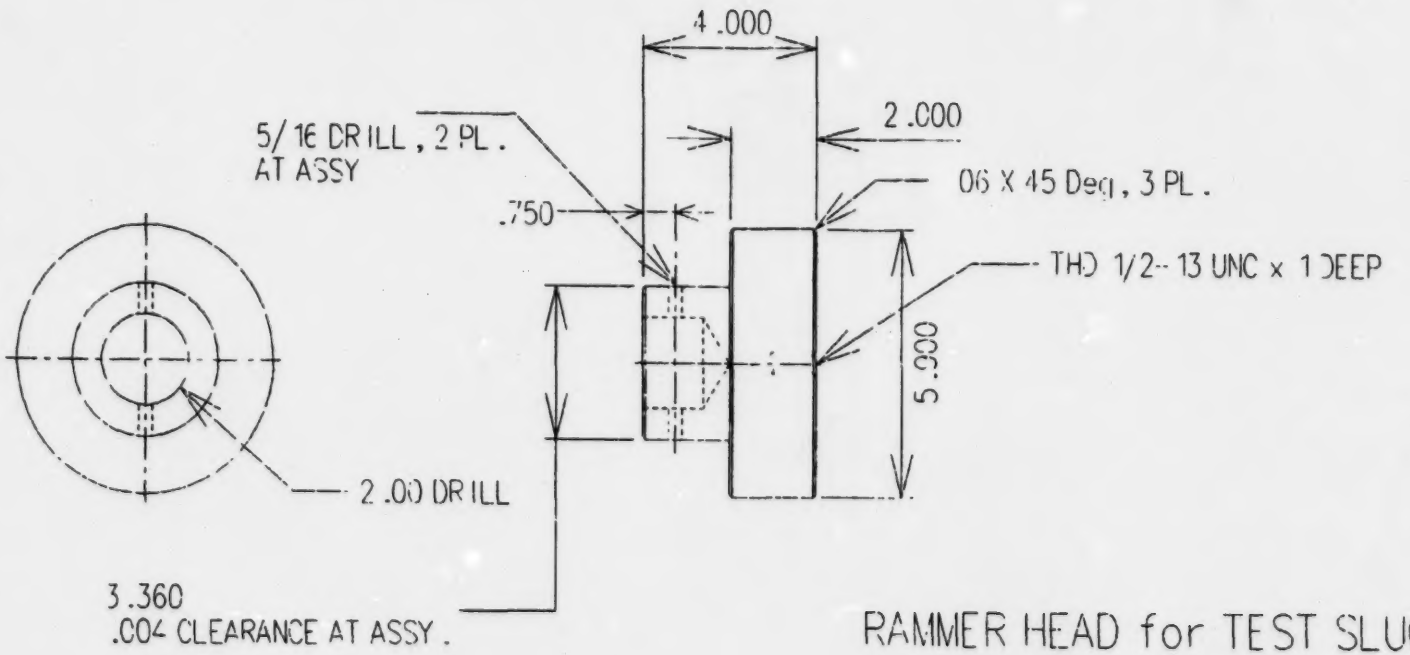
RAMMER TUBE
MAT'L : ALUMINUM ALLOY 6061-T6
DATE : 20 MAR 99
FILE : D2 RAMTUBE.CAD



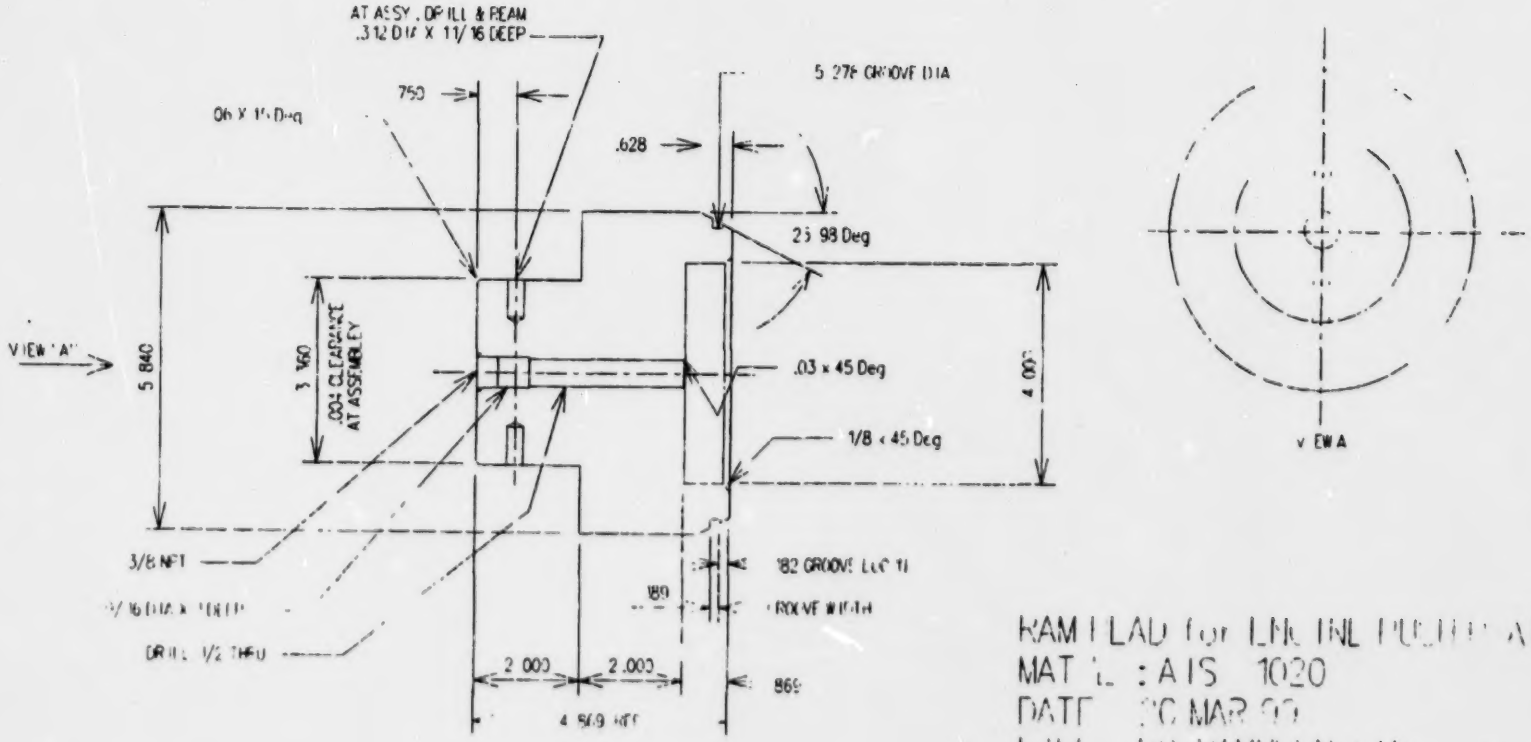
RAMMER GUIDE
MAT'L : A'SI 1020
DATE : 20 MAR 99
FILE : D2-RAMGUIDE .CAD



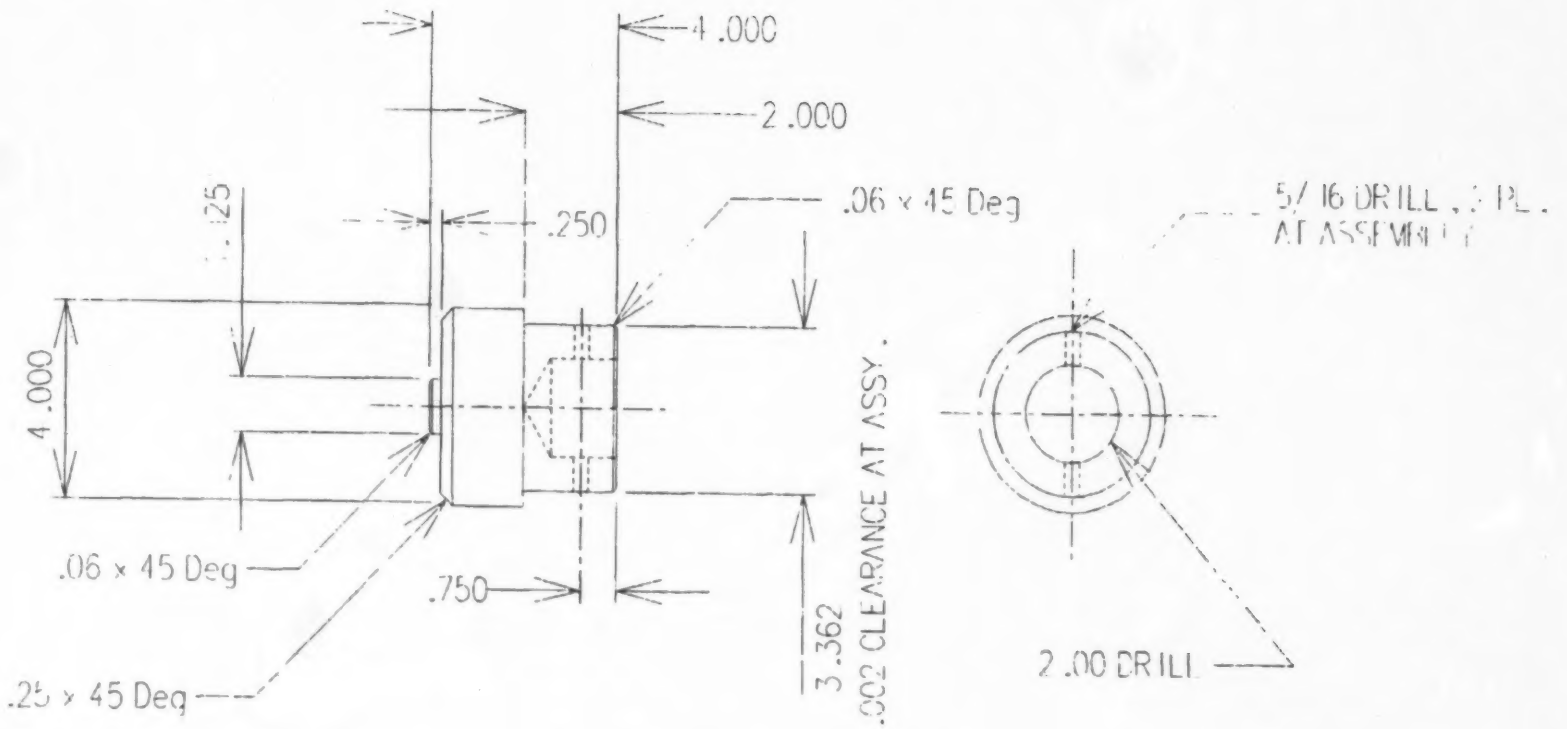
RAMMER PULLBACK FLANGE
MAT'L : AL . ALLOY 7075 T-6
DATE : 30 MAR 99
UNIT . IN PULLBACK . AD



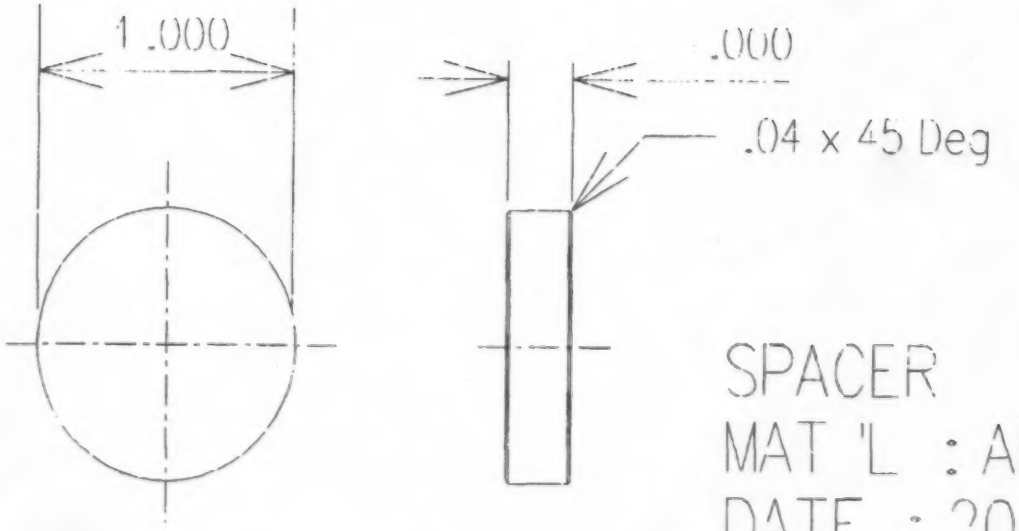
RAMMER HEAD for TEST SLUG
MAT'L : ALUMINUM ALLOY 7075-T 6
DATE : 20 MAR 99
[illegible] DR FAMILY OF



MATERIAL: AIS 1020



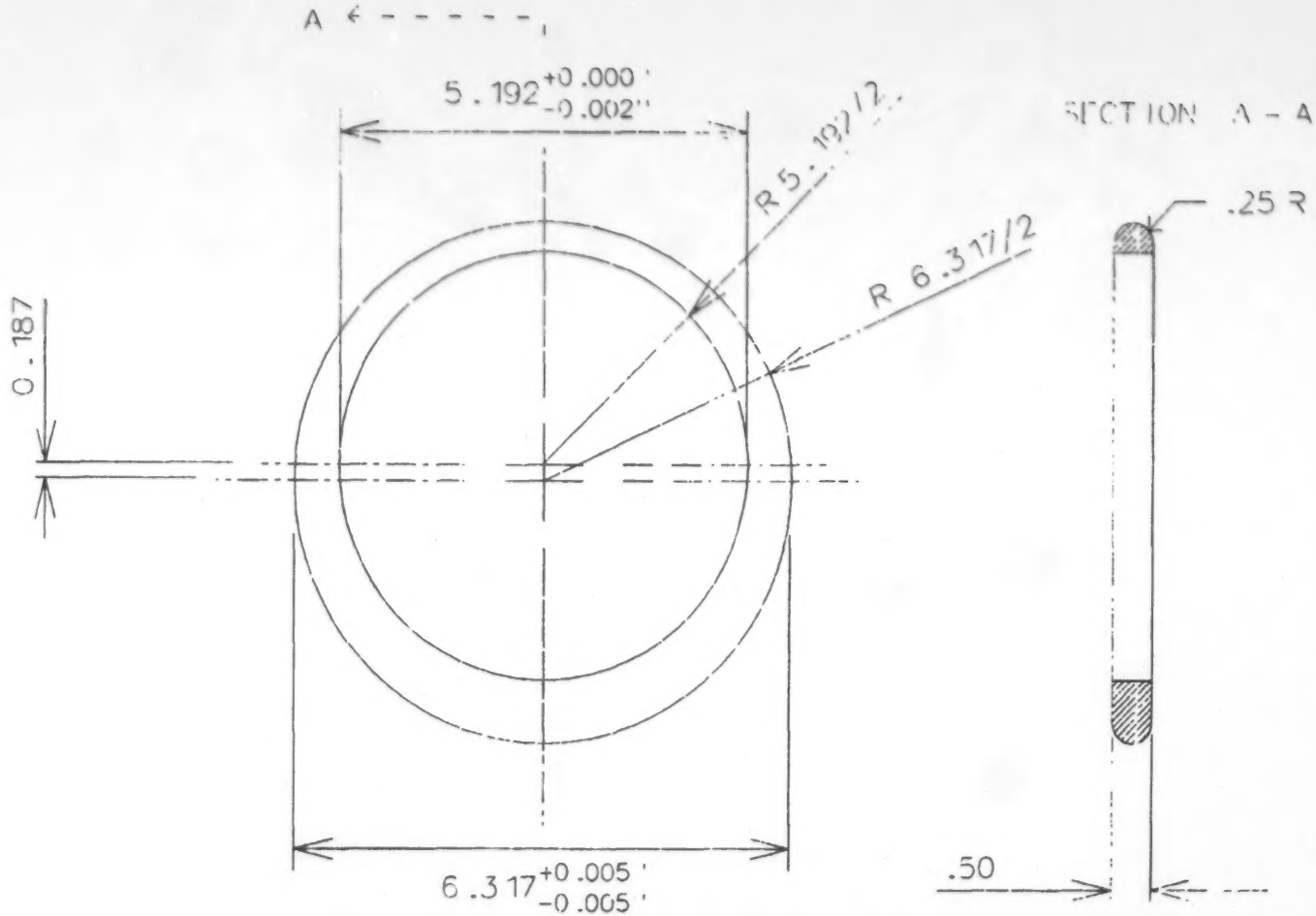
RAM TUBE END FITTING
MATL : ALUMINUM ALLOY 7075 T-6
DATE : 20 MAR 99
FILE : D2-ENDFITB.CAD



SPACER
MAT'L : AL ALLOY 7075 T-6
DATE : 20 MAR 99
FILE : D2-SPACER.CAD

Appendix D

Loading equipment details



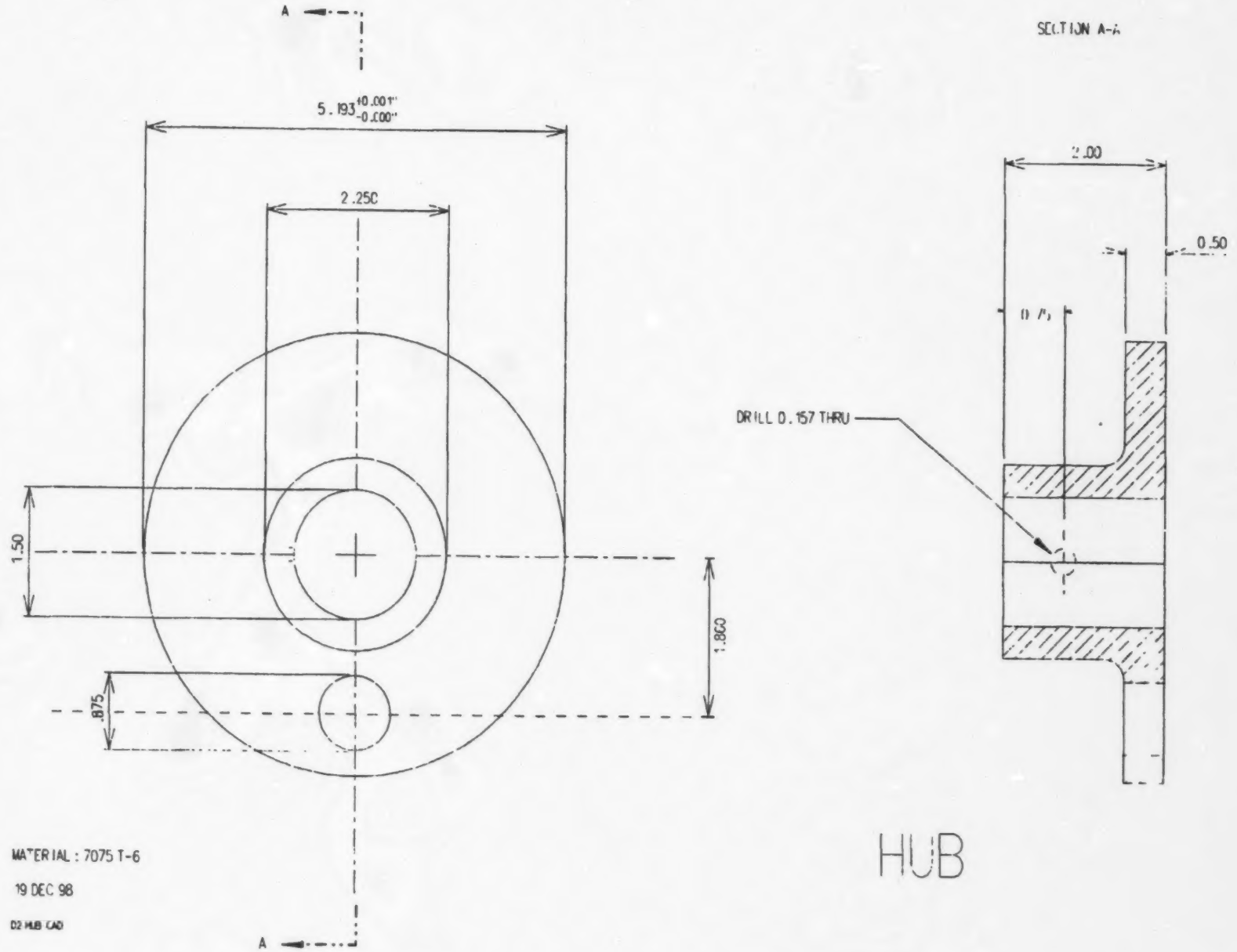
SECTION A - A

MATERIAL : 7075 T-6

ECCENTRIC

18 DEC 98

D2-ECCENTRC .CAD

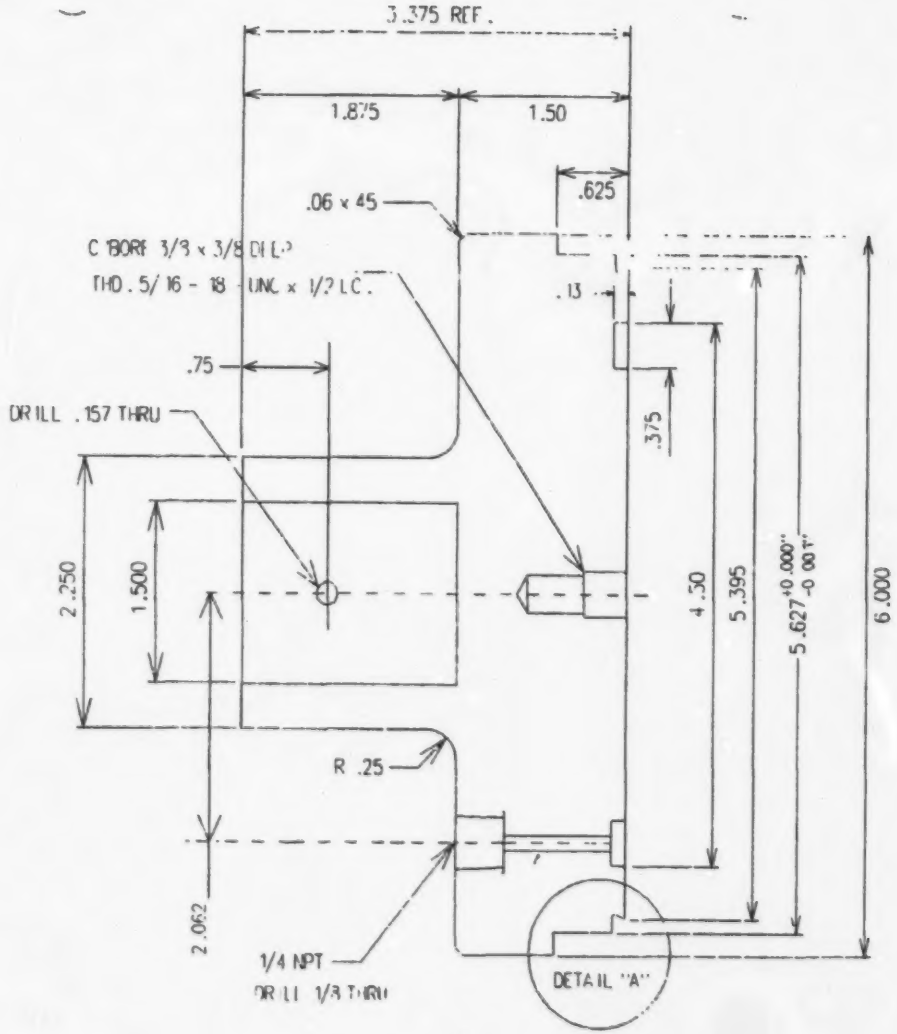


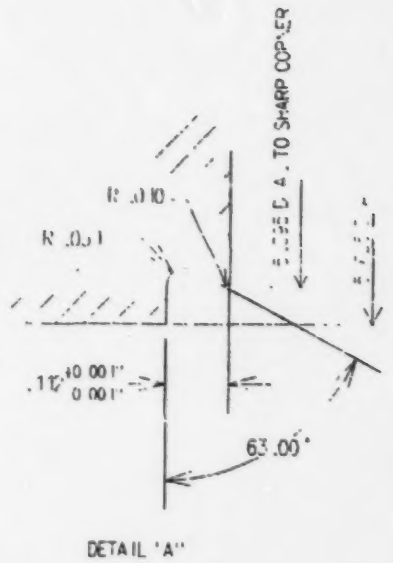
MATERIAL : 7075 T-6

19 DEC 98

D2 HUB CAD

HUB





MAT'L : 7075 T-6

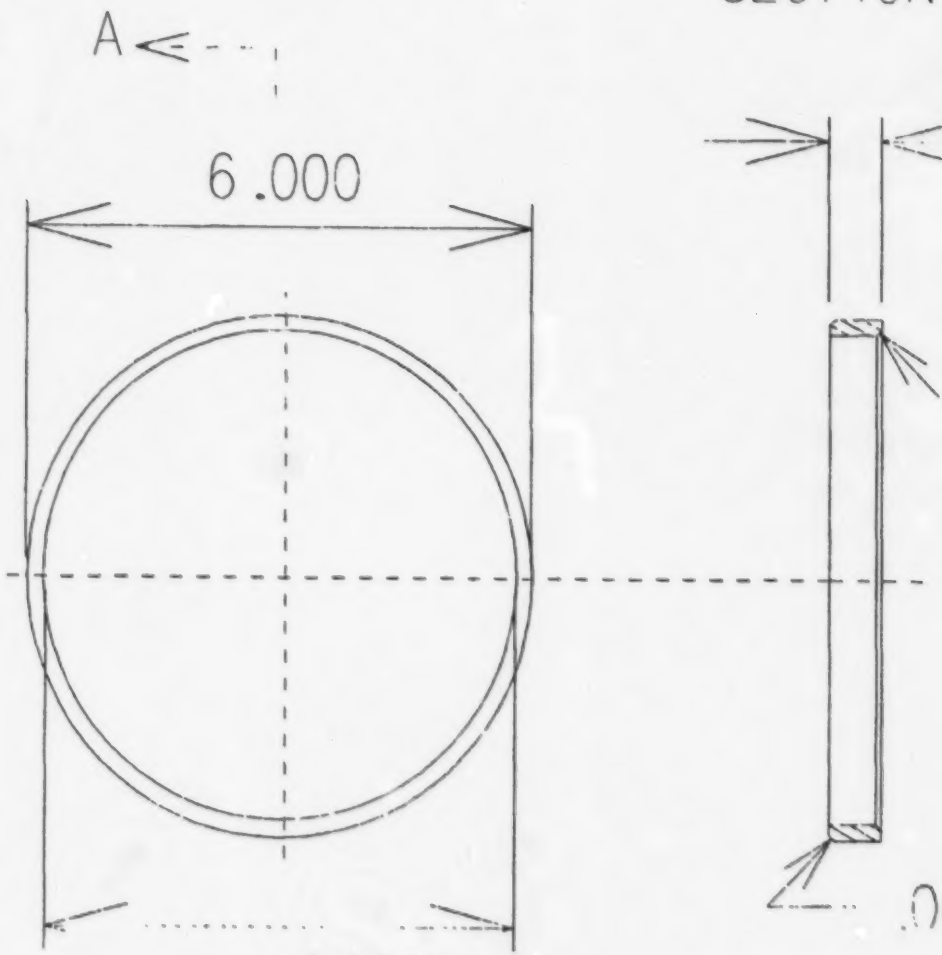
23 DEC 98

D2 TSADAPTR .CAD

ADAPTOR

TEST SLUG

SECTION A-A

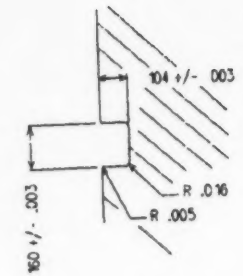


MATERIAL : 7075 T-6

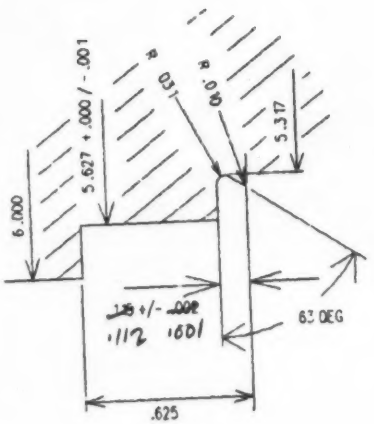
26 DEC 98 REV 0

RETAINER

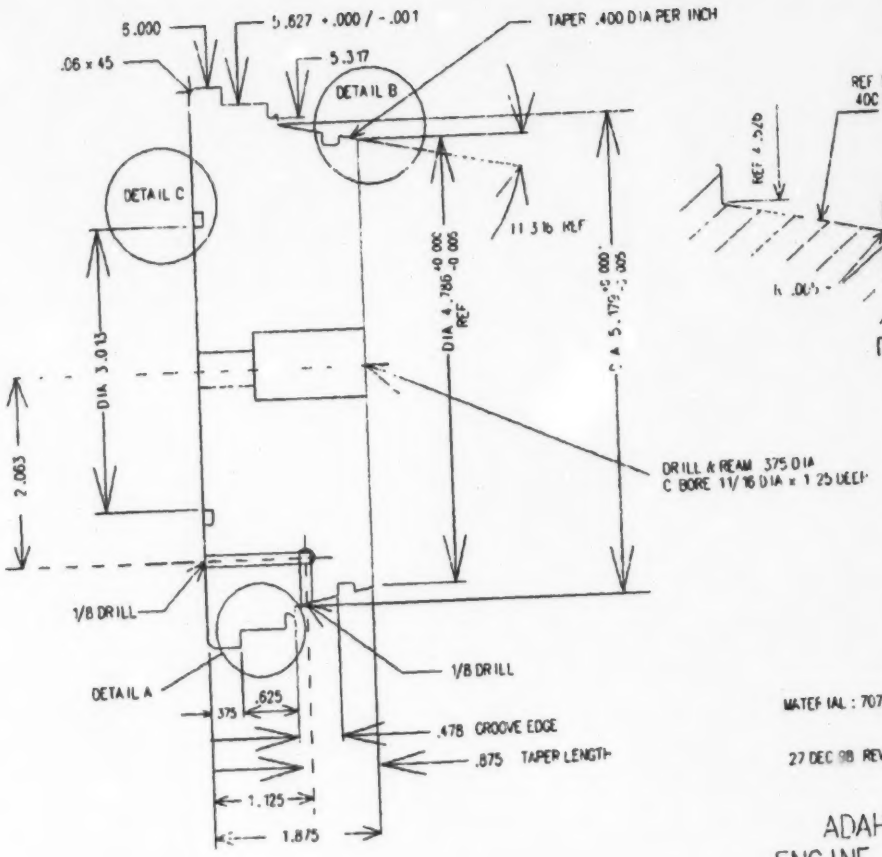
02 RETAINER CAD

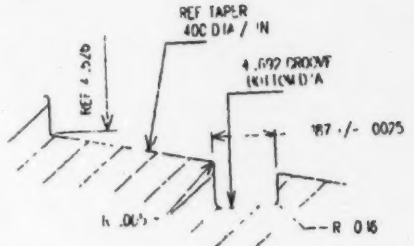


DETAIL C



DETAIL A





DETAIL B

MATERIAL : 7075 T-6

27 DEC 98 REV D

ADAPTOR
ENGINE BODY